PB-241 045

EVALUATION OF ALTERNATIVE METHODS OF FINANCING MUNICIPAL WASTE TREATMENT WORKS

Russell J. deLucia, et al

Meta Systems, Incorporated

Prepared for:

Washington Environmental Research Center

March 1975

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Evaluation of Alternative Methods for Financing Municipal Waste Treatment Works

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PE 1BA030 R/T 21 AXN 06

Meta Systems, Inc.
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68-01-2411

Environmental Protection Agency

Final Report

Environmental Protection Agency report number, EPA-600/5-75-001

This report is part of a continuing investigation by the EPA of alternative financing programs for treatment plant facilities undertaken in response to Section 317 of The Water Pollution Control Act Amendments of 1972. This report presents findings and recommendations regarding alternative financing programs. The report reviews the current programs, describes criteria for the evaluation of financing programs and discusses some differences of current programs in light of these criteria. Important features of alternative financing programs are discussed and analysis of features that could be changed to improve program preference according to the criteria is presented.

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EPA-600/5-75-001
March 1975

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By

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Contract No. 68-01-2411
ROAP 21AXN06
Project No. 1BA030

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ABSTRACT

This report is part of a continuing investigation by the EPA of alternative financing programs for treatment plant facilities undertaken in response to Section 317 of The Water Pollution Control Act Amendments of 1972. This report presents findings and recommendations regarding alternative financing programs. The report reviews the current programs, describes criteria for the evaluation of financing programs and discusses some differences of current programs in light of these criteria. Important features of alternative financing programs are discussed and analysis of features that could be changed to improve program preference according to the criteria is presented.

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ACKNOWLEDGMENTS

Meta Systems Inc wishes to acknowledge the guidance, reviews and professional critique provided by the Project Officer, Dr. Marshall Rose and his colleague Dr. John Goldstein. Many people, all too numerous to name, of EPA at both the regional and headquarters offices and of all fifty state agencies cooperated in providing information and guidance, and for this we express our gratitude.

EXECUTIVE SUMMARY

The Water Pollution Control Act Amendments of 1972 provide for 75 percent federal grants for treatment plant facilities. The method of financing the municipal expenditures mandated by the legislation was a major issue of concern in debates preceding the adoption of the Amendments. Section 317 of the Amendments specifically recognized the need for continuing investigation of alternative financing programs by the Environmental Protection Agency (EPA).

Three important issues raised by critics of the current financing program are:

1. the inefficiency in the allocation of resources to water pollution control;

2. the rate at which water quality improvement proceeds; and

3. the distributional and equity impacts of the program.

This study, one part of the continuing investigation of alternative financing programs for treatment plant facilities, considers these issues.

The study involved five principal tasks. First, criteria to judge alternative programs were developed. The criteria are: (1) effectiveness, as measured by the number of sources brought into compliance and/or pollutant mass removed; (2) efficiency, as measured by the price distorting effects of the alternatives; (3) equity, as measured by the equalizing effects of grants on per capita cost and cost per dollar of personal income across communities; and (4) feasibility, as measured by administrative requirements and political and legal precedents. These criteria were utilized in qualitative and quantitative analyses of existing programs and a range of suggested program modifications described in this report.

The current operation of the federal and state grants programs was then reviewed. Alternatives to current programs that may accelerate progress toward meeting the objectives of the 1972 Amendments in an equitable fashion were identified. Selected alternatives were analyzed against the above criteria using several quantitative techniques and qualitative observations. The quantitative analyses included a classification analysis of community types and a formal though simple model of the impacts on municipalities of alternative financing schemes. Due to data limitations these analyses were based on examples of municipalities with populations greater than 25,000.* Because inclusion of smaller communities in the analysis will broaden the range of per capita costs and the range of local waste reduction options (to make individual treatment and land disposal more attractive), our conclusions can only be expected to be reinforced. Finally, recommendations for federal policy to more effectively enhance the quality of our nation's waters and to more equitably share the costs of water pollution control were developed.

Two assumptions are important to this study. The first of these is that the spirit of the Amendments will be met. With certain specific exceptions all municipalities will have to meet the mandate of the law. The second assumption is that in general existing wastewater treatment systems are operated inadequately so that an incentive for better use of wastewater systems is an important consideration in the design of a financing program.

Findings of this study suggest need for increased awareness of the equity implications of financing alternatives. This is because the 1972 Amendments require all municipalities to control pollution (essentially no local choice exists) no matter to whom the benefits accrue, and because there are large differences in cost burdens placed on communities.

Seven characteristics are used to describe each financing alternative analyzed in this study: (1) allotment formula (for distribution to states); (2) grant formula (for distribution of funds to municipalities); (3) extent of wastewater system eligible for assistance; (4) size of construction loan; (5) size of operation and maintenance grant; (6) planning standards; and (7) plant performance standards.

---

* Data problems caused by delays in publication of the 1972 Census of Governments, costs of assessing socioeconomic information from the 1972 Census of Population and reliability of data in the 1973 Survey of Needs were considerable. We are confident, however, that best use has been made of available data and that further information will merely add corroborative detail.

The following pages present the findings and recommendations of this study.

FINDINGS

1. The effectiveness of any financing program designed to comply with the 1972 Amendments is primarily dependent on facility performance. A financing program can be designed to provide continuing incentives to municipalities to operate and maintain facilities effectively.

2. Grants for operation and maintenance of municipal wastewater treatment facilities cannot only provide incentive to keep facilities well-maintained and effectively operated but can also reduce local incentives to overcapitalize.

3. The current allotment formula provides no incentive to states to proceed with treatment facility construction at a faster rate than the national average or to ensure effective facility performance.

4. Current restriction of project eligibility to treatment plants and ancillary facilities results in certain cases in local adoption of waste treatment or reduction measures that are not least costly.

5. The community characteristics of population, growth rate, fiscal situation, wastewater system characteristics, industrial share of wastewater load and family income structure exhibit wide variations across the nation and along with varying ancillary needs imply large differences in per capita costs borne by communities under the existing federal construction grants program.

6. There are significant numbers of income poor, high treatment cost communities that bear an inequitable burden of the water pollution expenditures required by current legislation.

7. The current federal program of 75 percent construction grants results in only a modest federal contribution to the total municipal water pollution control costs mandated by the 1972 Amendments: less than 25 percent of total costs for large numbers of communities.

8. The present value of local costs is not significantly altered by selection of 10, 20 or 30 year design periods

for determination of treatment plant capacity. Consequently, localities will tend to choose the larger plant because of the difficulties of financing frequent bond issues and because of the political attractiveness of growth-oriented planning. Efficiency losses of such decisions may not be great; short-run budget implications could be considerable.

9. The alternative of a construction grant program that restricts the size of treatment facilities to meet only existing population makes more severe the variation in per capita costs across communities and encourages selection of inefficiently-sized facilities, many of which will rapidly become overloaded.

RECOMMENDATIONS

1. Federal financing programs should be altered to include provisions specifically designed to encourage effective plant performance. Programs might best include grants to assist with operation and maintenance costs. Supplemental operation and maintenance grants would increase the federal share of total costs, reduce incentives to overcapitalize and undermaintain, encourage treatment facility performance of an acceptable standard and modestly reduce the inequitable spread of per capita costs among communities.

In the event a supplemental operation and maintenance grant is not adopted, the construction grant program should be restructured as an annual transfer payment conditional on meeting performance standards. Improvements in BOD removal efficiencies of 5 to 15 percent may be expected at minimal increased cost with such performance incentives.

2. Waste reduction at least cost should be the criterion for eligibility of project components so that projects to reduce waste discharged to a treatment plant would be fundable. Furthermore, individual treatment systems should be preferred to centralized treatment where soil and hydrologic conditions permit and costs are lower.

3. A financing program should include requirements for planning and design review based on augmented cost-effectiveness guidelines. Incentives for engineers to recommend facilities more costly than necessary must be eliminated.

4. The grant formula design should include several components. Per capita financial burdens across municipalities

should be made more nearly equal with provisions in the formula to account for the cost effects of a municipality's population size, growth rate, income structure, percentage of industrial flow and the need to build ancillary facilities. Special compensating provisions should be made to municipalities to reflect the cost impact on low-income groups. The grant formula would achieve more equitable results if coupled with an operation and maintenance grant program.

5. The equity arguments in favor of a 75 percent construction grant mitigate against any reduction in the grant percent, especially considering the modest federal contribution to the total cost to municipalities of nationally-mandated water pollution control, unless such a reduction is coupled with an operation and maintenance grant and a new grant formula for per capita cost equalizing among communities.

6. The allotment formula should continue to be based primarily on needs with an incentive structure to induce use of state capital grant monies for communities for which immediate federal aid is not available (but which have complied with cost-effectiveness guidelines) and to foster operation and maintenance programs that are oriented toward improving plant performance. Illinois has a program of the first type; New York has one of the second.

SECTION 1

INTRODUCTION

DESCRIPTION OF PROBLEM

A continuing theme in legislative and executive discussions of water quality improvement has been the appropriate means to finance pollution abatement. In debates preceding adoption by the U.S. Congress of the Water Pollution Control Act Amendments of 1972, methods of financing the enormous expenditures required for the municipal waste discharge reductions mandated by the Amendments were a major concern.* The Amendments as finally adopted and passed over the President's veto provide for 75 percent federal grants for facility construction with no specified state participation required. (The Senate bill provided for a 70 percent federal grant if the state participated with a 10 percent grant, and the House bill provided for a 75 percent federal grant if the state participated with a 15 percent grant or loan. No state participation would have led to further grants of 60 percent under either bill.) The Amendments further provide for an Environmental Financing Authority to assure municipal access to funds to finance its share of project costs and for an allocation of funds among states according to need for treatment plant construction.

The 1972 Amendments also contain Section 317 mandating the continuing investigation of "alternative methods of financing the cost of preventing, controlling, and abating pollution..." as directed in the Water Quality Improvement Act of 1970. Given the diversity of proposals debated prior to adoption of the 1972 Amendments, the current range of state-level financing mechanisms, and experience to date with the financing of municipal wastewater treatment works, a number of outstanding issues present themselves for investigation under Section 317. These issues relate to increased efficiency in allocation of resources to water pollution control, to the rate at which water quality improvement proceeds, to administrative feasibility and the distributional and equity impact of alternative mechanisms.

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* Library of Congress, "A Legislative History of the Water Pollution Control Act Amendments of 1972," Government Printing Office, 1973.

As one element of the continuing study mandated by Section 317 of the Amendments, this study focuses on alternative federal programs for financing municipal wastewater treatment works. Before discussing the organization of this report and the study approach, it may be helpful to briefly describe the physical structure and characteristics of municipal wastewater systems. The following part of Section 1 discusses the assumptions underlying this study and the criteria against which alternative financing programs are analyzed.

WASTEWATER SYSTEM DEFINITION

From a practical point of view once a community is supplied with at least 5 gallons per capita per day, it becomes absolutely essential to provide for the removal of the spent water through individual or community sewer systems. Although 30 percent of the present U.S. population lacks a community sewerage system -- usually in such cases disposing of the wastewater by individual systems consisting of subsurface irrigation -- the remainder of the population, however, will discharge their wastes into community sewerage systems constructed over many decades and sometimes centuries.

Wastewater systems* can be described as consisting of collection, treatment and disposal works, although frequently systems are without treatment works. Collection works transport both wastewater from households (domestic sewage) and wastewater from manufacturers (industrial wastes) thus municipal sewage generally includes both domestic and industrial wastes. If the collection works transport storm water runoff as well as municipal sewage, the transporting conduits are called combined sewers. If storm water and municipal sewage are collected and transported separately, such systems are referred to as separate. Combined sewers are usually found in old cities such as Boston, Massachusetts. In many areas systems are a mixture of combined sewers in older districts and separate systems in newer areas. The collection works usually consist of a tree (bush) type network of sewers often of rectangular or radial pattern (see Figure 1). The networks frequently have an implicit hierarchy; wastes are discharged into lateral sewers, laterals to sub-mains, sub-mains to main (trunk) sewers (or to interceptors), interceptors to outfalls or to treatment facilities. The sewer systems are usually free flow and drain downhill except where pumping stations and force mains (sewers flowing under pressure) are present for topographical or economic reasons.

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* This system definition draws from Fair, Gordon Maskew and John Charles Geyer, Water Supply and Waste-Water Disposal, John Wiley & Sons, Inc., New York, 1954.

The term interceptor is also used in the case when effluent from one or more treatment plants is transported for additional treatment or ultimate disposal.* In combined systems, interceptors (destined for a treatment plant) generally are designed to carry the maximum dry weather flow or some multiple of average dry weather flow. The additional storm runoff is allowed to overflow into the receiving water body that the interceptor is designed to protect. Some combined system interceptors and associated storm water works have been designed to partially capture the flushing portion of storm water runoff and the pollutant load it carries either for separate treatment or treatment with the municipal sewage.

Infiltration and exfiltration can be major problems in wastewater systems; both are functions of the height of the groundwater table, the soil type, the tightness of sewer joints and the level of maintenance of the sewer system. Infiltration -- the entry of groundwater, either directly from the saturated ground or from percolation following rainfall -- is a problem because it reduces the capacity of the sewer to transport wastewater and increases the flow which must be handled by the treatment works. Exfiltration, the loss of wastewater from sewers, is undesirable since it may pollute local groundwaters.

Municipal treatment works are frequently classified as primary, secondary or tertiary treatment plants depending on their level of pollutant removal. The 1972 Amendments have introduced a new set of terms -- best-practicable and best-available. Operationally, on the basis of EPA "guidelines,"

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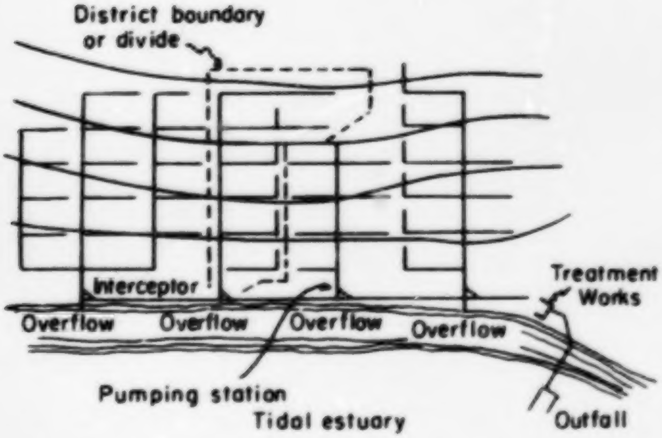
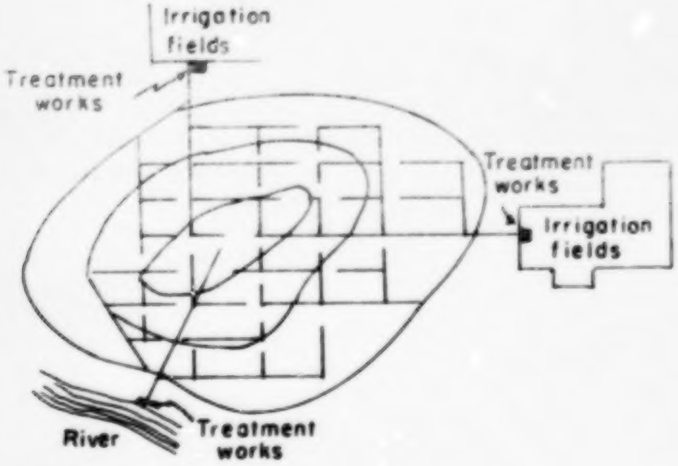
* In reports by different consulting firms or engineering texts, the usage of the different terms, main sewer, trunk sewer, interceptor, etc., is not without inconsistencies.


District boundary or divide
Interceptor
Overflow
Overflow
Overflow
Overflow
Treatment Works
Pumping station
Tidal estuary
Outfall

(a) Rectangular pattern


Irrigation fields
Treatment works
Treatment works
Irrigation fields
River
Treatment works

(b) Radial pattern

Figure 1 Typical wastewater systems*

after Fair, G.M., Geyer, J.C., and D.A. Okun, Water and Wastewater Engineering, Vol. 1, Water Supply and Wastewater Removal, John Wiley & Sons, Inc., New York, 1966.

these are equivalent to "super" secondary and tertiary type treatments.

Primary treatment usually consists of one or more treatment units based on physical processes, but often connotes any set of processes preliminary to secondary treatment. Frequent process types are: screening for the removal of bulky floating or suspended matter and sedimentation for the removal of some of the heavier suspended matter. Adequately maintained and operated primary treatment plants remove some 30-35 percent of the organic pollutant and approximately half of the suspended solids in municipal sewage.

Secondary treatment frequently consists of a series of treatment units: one biological process and one or more complementary physical (sedimentation) and/or chemical (chemical precipitation) processes. The most common of these biological processes are activated sludge processes, trickling filters and stabilization ponds. The general principle is the use of biological growth to convert the suspended and dissolved material into settleable solids -- the secondary sludge. Secondary treatment works frequently have chlorination units for the destruction of pathogenic bacteria and other organisms. Adequately operated and maintained secondary treatment works can be expected to remove 80-90+ percent of the organic pollutant and 80+ percent of the suspended solids.

Tertiary treatment works usually consist of additional (after secondary biological) chemical and/or physical treatment processes. These processes are normally aimed at Nitrogen and/or Phosphorus removal, e.g., Phosphorus precipitation or Nitrogen stripping. However, additional removals of organic and/or suspended matter can also be the design aim. The latter design aim is frequently achieved by the addition of a filtration process after biological secondary creating a "super" secondary treatment plant. Further process additions to such a treatment plant lead to a tertiary type plant. Removal percentages in excess of 99 percent can be achieved, but at high cost.

In some cases the chain of primary and biological secondary is replaced by a series of physical/chemical processes.

Irrespective of the processes used, there are both liquid effluent and either solid (dewatered sludge) or liquid sludge suspension requiring ultimate disposal. The usual case is for liquid effluent disposal to a water source and sludge transported either to land disposal or ocean disposal. In some cases there is land disposal of both liquid effluent and sludge.

While the focus of this study is on the financing of treatment works at the end of the wastewater system, there are strong efficiency arguments for considering financing programs that include a larger part of the wastewater system.* This point is briefly discussed in Section 3 of this report.

ASSUMPTIONS OF THE STUDY

Existing wastewater systems represent a significant amount of capital in place and current projections of necessary capital needs to meet the requirements of the Amendments are staggering.+ There is an obvious need to make better use of existing capital and to operate new capital investments properly. One assumption in this study is that incentive for better use of the wastewater systems is an important, if not primary, part in design of financing alternatives. A very cost-effective expenditure on wastewater systems is better maintenance and operation.

Another important assumption in this study is that the spirit of the 1972 Amendments will be met; namely, that all municipal sources will be constrained by federal mandate to achieve at least best-practicable treatment. This markedly limits the municipal options examined in our analysis. The only relevant questions are: how big a plant to build and whether to initially build and operate a secondary, best-practicable, or best-available treatment facility.

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* The same effectiveness argument can made regarding maintenance and operation of the collection system.

+ "Costs of Construction of Publicly-Owned Wastewater Treatment Works, 1973 'Needs' Survey," Report to the Congress, U.S. Environmental Protection Agency, Washington, D.C., 1973.

The literature* on federal cost-sharing programs in water resources investment emphasizes that local cost-sharing proportions should be equal to the ratio of local to social benefits received at the margin. The authors maintain that this rule does not readily apply to the problem of financing treatment facilities under the 1972 Amendments, since under the Amendments there is little or no choice allowed the community with respect to controlling pollution or not.

The Amendments set the restoration and maintenance of the chemical, physical and biological integrity of the nation's water as a national goal and set a policy of federal financial assistance in the construction of publicly owned waste treatment works.

There are subtle political and economic distinctions between the water pollution control program as defined by the Amendments and other water resources programs. The arguments for local cost-sharing in proportion to benefits for other programs are in general valid.+ Much of the literature regarding cost-sharing is based on examples of flood control, irrigation, recreation and navigation. Three characteristics are pertinent to the cost-sharing argument:

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* See, for example, Loughlin, J. C., "Cost-Sharing for Federal Water Resource Programs with Emphasis on Flood Protection," Water Resources Research, VI, No. 2; and Marshall, H. E., "Economic Efficiency Implications of Federal-Local Cost Sharing in Water Resource Development," Water Resources Research, VI, No. 3.

The recent National Water Commission report criticizes federal subsidies in general, and EPA's present financing program in particular, as leading to inefficiencies. See Water Policies for the Future, final report of the National Water Commission to the President and to the Congress of the United States, Washington, D.C., U.S. Government Printing Office, 1973.

+ However, studies making this argument are often insensitive to the question of incidence of the local share of costs on lower income groups.

1. the presence of local benefits;
2. acceptable state-of-the-art techniques for quantitative benefit estimation; and
3. the existence of local or state choice regarding project adoption.

The first characteristic is usually present to at least some extent. However, investment in water quality control is perhaps the strongest example in the water sector of externalities -- and frequently much if not almost all of the benefits accruing to the downstream users. The present mandated program dictates a large percentage* of local cost burden independent of the implicit benefit share. The latter two characteristics are not present for water pollution control programs.

The Amendments provide for partial financing of facilities but mandates local participation. The approach is not one of providing only an incentive, but rather legislating a mechanism to enforce mandated behavior while providing a sweetener of partial financing.

The legislation is quite unique in this sense. It is markedly different from other water resources, environmental, health, education, and welfare programs of fiscal federalism. The universal characteristic found in other categorical programs is partial federal grants as an incentive for local or state governments to participate and thus provide a specific public good. In all cases participation is not mandatory.

The study does not argue that federal goals with respect to equity/distributional issues are to be attained solely via the environmental quality program but rather that more heed must be paid to these issues in evaluating environmental quality policy; this study attempts to do so.

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* Recall that present federal cost-sharing program supports 75 percent of capital costs and no OM&R costs. As the analysis in Section 4 indicates, this implies that the community share of total treatment costs is at least 50 percent and frequently as much as 75 percent.

CRITERIA

Federal financing programs are evaluated against four criteria: effectiveness as measured by number of sources brought into compliance and/or mass of pollutant removed; efficiency as measured by the resource costs of price distorting effects of grants; equity as measured by the equalizing effects of grants on per capita cost and the cost per dollar of personal income across communities; and feasibility as measured by administrative requirements as well as political and legal precedents.

These criteria are utilized in qualitative and quantitative analyses of existing programs and of a range of suggested program modifications. As noted earlier, equity assumes major importance because of the study's findings with respect to the large differences in cost burdens placed on unlike communities by uniform, national-interest motivated treatment requirements.

FINANCING ALTERNATIVES

Financing alternatives are described according to characteristics, each of them variable over a range in order to achieve the desirable federal program. These characteristics are: (1) allotment formula (for distribution of funds to states); (2) grant formula (for distribution of funds to communities); (3) extent of wastewater system eligible for assistance; (4) size of construction loan; (5) size of operation and maintenance grant; (6) planning standards; and (7) plant performance standards.

REPORT ORGANIZATION

Section 2 of this report reviews the current federal and state programs for aiding municipalities to finance construction of wastewater treatment plants. Section 3 describes the four criteria for financing program evaluation and enumerates some deficiencies of current programs seen in light of these criteria. Section 3 then discusses important features of alternative financing programs and identifies those features that could be changed to improve program performance according to the criteria. Section 4 continues this analysis with quantitative estimates of the impacts of alternative financing programs and will summarize conclusions pinpointing current program deficiencies and recommending action for improvement.

SECTION 2

THE PRESENT SITUATION

BACKGROUND

In debates preceding adoption by the U.S. Congress of the Water Pollution Control Act Amendments of 1972, a major set of issues revolved about methods of financing the enormous expenditures required for the municipal waste discharge reductions mandated by the Amendments.*

Section 317 of the Amendments recognizes the need for continued analysis of the means of financing and states that the Environmental Protection Agency

> shall continue to investigate and study the possibility of alternative methods of financing the cost of preventing, controlling and abating pollution as directed in the Water Quality Improvement Act of 1970.

This study is one of a series of complementary studies undertaken under the impetus of Section 317.

Given the diversity of proposals debated prior to adoption of the 1972 Amendments, the range of state-level financing mechanisms, and experience to date with the financing of municipal wastewater treatment works, a number of outstanding issues present themselves for investigation under Section 317. These issues relate to increased efficiency in allocation of resources to water pollution control, to the rate at which water quality improvement proceeds, and to the administrative feasibility and distributional equity impacts of alternative mechanisms. The focus of this study is on the examination of these issues as they relate to the federal financing of municipal wastewater treatment plants and associated ancillary works only. Other studies currently underway for the Environmental Protection Agency (EPA) are examining financing alternatives for other parts of the waste generation/collection/transport/treatment system.

This section of the report describes the present situation including the current federal grant program, a summary discussion of the state programs, and a brief discussion of local financing programs.

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* Library of Congress, "A Legislative History of the Water Pollution Control Act Amendments of 1972," Washington, D.C., Government Printing Office, 1973.

THE CURRENT FEDERAL GRANT PROGRAM

The most significant features of the current construction grant system are: allotments, priority lists, facility planning, reimbursement, application and award, allowable project costs, and the grant percentage. Each of these features is discussed briefly here; for further details, see Appendix B.* We should point out that the system is relatively new; regulations, guidelines, and details are continually being updated.

Allotments

The 1972 Amendments provided for authorizations of $5, $6, and $7 billion for fiscal years ending June 30, 1973, 1974, and 1975, respectively. These authorizations in theory provide the basis for an allotment of grants to the states according to the ratio that the most recent congressionally approved estimate of the cost of constructing all needed publicly owned wastewater treatment works in a state bears to the most recent congressionally approved estimate of the cost of construction of all publicly owned wastewater treatment works in all the states.+ In practice outlay estimates of total allotment are based not on authorizations but on a "normal" rate of grant award based upon previous (i.e., pre-1972 Amendments) experience modified by new provisions of the 1972 Amendments. Thus, for fiscal years ending June 30, 1973, and June 30, 1974, total allotments of $2 billion and $3 billion, respectively, were used.

Under the 1972 Amendments no appropriation is required to incur contractual obligations, i.e., to award grants. Once a grant application is approved by the EPA, that approval becomes an obligation of the federal government to pay its share of the project costs; specific appropriations must then be sought to liquidate the contractual obligations so incurred by the award of a grant. Knowledge of the level and time pattern of obligations allows accurate determination of the pattern of outlays that will be necessary.

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* Basic sources were: Michael Quigley and Michael Cook of the construction grants program; a May 16, 1973 memo of Robert Fri, "Grants for the Construction of Wastewater Treatment Works;" a draft of proposed regulations for grants (40 CFR 35.900 et seq.) December 4, 1973; and other regulations, guidelines and planning documents.

+ See P.L. 92-500, Section 205, and Table III of House Public Works Committee Print No. 92-50; and P.L. 93-243, and Tables I, II, and III of House Public Works Committee Print No. 93-28; for the actual ratios to be used.

State allotments are available for obligation for a period of one year following the close of the fiscal year for which the sums were authorized. Funds remaining unobligated at that time are reallocated to the other states on the basis of the most recent allotment ratio. Funds obligated but remaining after final payment or project termination are credited to the state as an additional allotment sum.

Project Priority Lists

States submit to EPA regional administrators "project lists" that provide the basis for the priority ranking of the projects to be considered for grant approval. Preparation of this list requires five steps: (1) annual state strategy submission assessing water pollution problems and control strategies; (2) state segment priority list preparation ranking all segments in a state taking into account severity of pollution problems, population affected, need for preservation of high-quality waters, and other national priorities; (3) municipal discharge inventory list preparation according to 303(e) guidelines; (4) project selection criteria statement reflecting segment criteria and excluding criteria based on financial need, municipality's readiness to begin construction, or ability to meet 1983-1985 goals; and (5) project list preparation applying the criteria of the fourth step to the municipal discharge inventory list of the third, but including only projects that can be funded from current allotment funds.

Regional administrators in reviewing project lists have been advised in the "Water Strategy Paper"* to modify state lists according to the following guidelines stated in order of importance:

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* U.S. Environmental Protection Agency, "Water Strategy Paper, Second Edition, A Statement of Policy for Implementing the Requirements of 1972 Federal Water Pollution Control Act Amendments," Draft, December 7, 1973.

a. Projects which are required to meet water quality standards and which must comply with the enforceable provisions of the Law--i.e., treatment works that provide secondary treatment or any higher level of treatment dictated by water quality standards. Included in this category are ancillary improvements which must be done in conjunction with an award, such as a cost-effective solution to certified excessive infiltration into sewers.

b. Projects which are not required to meet water quality standards but which must comply with the enforceable provisions of the Law--i.e., treatment works that provide secondary treatment. This would include ancillary improvements as described in Step a. above.

c. Projects that are desirable in terms of water quality improvement, but against which the enforceable provisions of the Law for secondary treatment can not be applied--e.g., storm and combined sewers. These projects will be subject only to the treatment requirements necessary to meet water quality standards.

d. Projects which are not dischargers--e.g., collection sewers or recycled water supplies. Collection sewers may be given higher priority where there is a special problem of groundwater contamination, or where they are an integral part of a waste treatment system (which includes a treatment plant) for a community which previously was without such a system. This ranking of importance does not mean that all projects in class a. must be funded before initiating projects in class b., and so forth.*

Public hearings must be held on project lists and project list modifications.+ The lists are submitted to regional administrators within 60 days of any funds allotment to the states; the regional administrator has 30 days to act. Not less than 5 percent of each allotment for fiscal year 1975 and later years must be reserved for grant increases.

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* "Water Strategy Paper," pp. 19-20.

+ This requirement is waived for fiscal year 1974 funding if time is insufficient, and may be waived for modified lists in the future.

EPA requirements explicitly give responsibility to the states for determining the amount and timing of federal assistance to each municipality.

Facility Planning

The current water quality legislation provides for a three-step funding of wastewater treatment plants. The first step is for the municipality/state to submit facility plans and related studies to the EPA; in the second step, construction drawings and specifications and sewer system rehabilitation plans are submitted (if required); and, last, the building of an operable wastewater treatment works is accomplished. These steps are referred to hereafter as Step 1, 2 and 3, respectively. Other arrangements are possible but additional requirements must be met. For these specifics see Appendix B.

Reimbursement

If Step 1 planning is initiated without a federal grant prior to July 1, 1974, and is completed to the standards set forth in published regulations, then reimbursement is allowed in conjunction with the award of a Step 2, Step 3, or the combination Step 2/3 grant.

Step 2 costs for preparation of final construction drawings and specifications initiated prior to July 1, 1974 may also be reimbursed as part of a subsequent grant under the priority system.* No Step 3 grant can be awarded if initiation of project construction has occurred.

Grant Application and Approval

Applications for grants and grant amendments are first submitted to the state agency to be certified as to priority and to be forwarded to the EPA regional office. Grant approval demands a multitude of requirements be met. Generally, these requirements include submitting plans that meet certain grant and physical plant criteria; that consider priority and allotment conditions; that have obtained and complied with necessary permits, regulations, and laws; and that do not violate certain cost specifications. The complete and detailed list of requirements is not presented here because of its length, but is detailed in Appendix B.

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* Step 1 and Step 2 reimbursement is permitted under draft regulations although there is a possibility this will change before publication of final regulations.

Grant Award

Approval of a grant application constitutes a contractual obligation of the federal government to pay its share of allowable project costs. Grants are made directly to the municipality.

Grants will normally be for Step 1, Step 2, or Step 3 projects, but where compelling water quality enforcement considerations, serious public health problems, or minimization of administrative requirements for small projects warrant, a Step 2/3 grant may be awarded. Detailed construction drawings and specifications must be approved by EPA before initiation of construction.

Any grant must be for an "operable" portion of a wastewater treatment works; the treatment works do not (under draft regulations) have to be "complete." Consequently, although no grant for a treatment works may be made from funds allocated for any fiscal year beginning after June 30, 1974 (unless provision is made for application of best-practicable treatment over the life of the treatment works), a grant may be made for an operable portion of a treatment works where that portion does not provide best-practicable treatment if the complete works will provide best-practicable treatment and a schedule for completion of the complete works is submitted to EPA.

In addition to grant conditions already enumerated and given in Appendix B, the following additional conditions are imposed on grant awards: conditions prohibiting nonrestrictive specifications but including bonding and insurance, equal employment opportunity, and EPA access conditions, provision for an operation and maintenance plan including a manual, an emergency response program, properly trained personnel, adequate budget, operational reports, and laboratory testing; and the institution of an affirmative program for the utilization of small and minority businesses in the case of grants over $10 million. Additional conditions are imposed on contracts for personal and professional services, and for engineering, planning, architectural and related services, including prohibition of the cost-plus-percentage-of-cost or percentage-of-construction-cost types of fee contracts, and on construction contracts.

Project Costs

Those project costs that are allowed in the current federal grant program include salaries and consultant services; materials and laboratory supplies; preparation of reports and drawings; planning, compliance, and evaluation costs; and costs related to physical relocation, construction, and landscaping. Costs that are not allowed are for planning and costs not directly related to the project or not approved; early project completion bonuses; personal injury compensation; fines, penalties, or interest; and local operating expenses and site acquisition. Complete lists for both allowed and unallowed costs are presented in Appendix B.

Grant Percentage

Discussion is ongoing within EPA regarding the possibility of less than 75 percent grants. In the May 16, 1973 memo of Robert Fri a provision is made for supplemental funding whereby states, after showing financial ability and intent and after waiving all reimbursement claims, can make up the difference between the actual EPA grant (when it became necessary to provide less than 75 percent grants) and the eligible (75 percent) EPA rate. Each municipality's share would not be allowed to exceed 25 percent.

THE STATE PROGRAMS: A SUMMARY

In general terms, well-developed programs exist in the large, urbanized states (e.g., Illinois, New York) while many of the less-developed states have no programs (for example, Arkansas and North Dakota). The majority of state programs fall between these two extremes. Table 1 presents the elements of each of the state's programs. There are three specific types of programs: construction grant programs, construction loan programs, and programs offering operation and maintenance subsidies.

Table 1. STATE PROGRAMS FOR FINANCING OF MUNICIPAL WASTE TREATMENT WORKS

STATE	CONSTRUCTION GRANT DETAILS	CONSTRUCTION LOAN DETAILS	O&M PROGRAM DETAILS	BOND ASSISTANCE DETAILS	NOTES
Alabama	No	up to 100%	No		Loan program called "grant" for PL 660.
Alaska	12 1/2% with EPA grant; up to 25% if eligible but no federal grant.	No	No		Pre-financing of federally approved projects.
Arizona	5% matching funds for municipalities receiving a 75% EPA grant; nothing for municipalities receiving no EPA grant.		No		
Arkansas	No		No		
California	12 1/2% matching funds for municipalities receiving 75% EPA grant; nothing if no EPA grant.	for "hardship" cases	No		
Colorado	5% for municipalities receiving EPA grants; 25% for municipalities which are eligible for, but do not receive, EPA grant.				
Connecticut	15% for municipalities receiving EPA grants; 30% for municipalities which are eligible for, but do not receive, EPA grant.		No		
Delaware	15% for municipalities receiving EPA grant; nothing for municipalities without EPA grant.		No		Prior to 1972 had a "phased funding scheme" for allocation of state funds - proved to be unworkable.
Florida	No Bill for grants up to 25% enacted in 1967, but no funding provided.	No (see notes)	No	If do not get EPA grant.	Loan program for pre- and short term-financing exists.
Georgia	Program has been on books for 10 years but only funded for 1970. Applications not tied to EPA grants; financial need, however, is considered.				
Hawaii	15% for municipalities receiving EPA grants; up to 100% for municipalities eligible for, but not receiving, EPA grant.	No	No		State pre-finances the EPA grants to municipalities.
Idaho	15% for municipalities receiving EPA grants; nothing for municipalities without an EPA grant.		No		
Illinois	After all federal funds for Illinois are allocated, will give 75% state grant to those municipalities which are eligible for, but do not receive, a federal grant.		No		

Table 1. (continued)

STATE	CONSTRUCTION GRANT DETAILS	CONSTRUCTION LOAN DETAILS	O&M PROGRAM DETAILS	BOND ASSISTANCE DETAILS	NOTES
Indiana	15% for municipalities receiving EPA grants; nothing for municipalities not receiving EPA grants.	No	No		(Minor) planning loans available (of minor importance).
Iowa	No At present no program, but likely that 5% matching grant will be enacted.		No		
Kansas	No	No			
Kentucky	No No state program but possibility of 5% grant from Appalachian Regional Commission.	No Nothing at present but being considered.			
Louisiana	No (see "loans")	Under PL 660 offered "grants" of 25% (with EPA 55% grants) - in reality these were loans. Program now effectively abolished.	No	State law provides for creation of districts for this purpose - has not yet been utilized.	
Maine	15% for municipalities receiving EPA grant (although up to 25% provided for in law). Nothing for municipalities which do not receive EPA grant		No		Non-interest loans available for planning.
Maryland	12 1/2% grant to municipalities receiving 75% EPA grant; up to 87 1/2% to municipalities EPA eligible but no funds and project considered urgent; nothing if not EPA eligible.	up to $250,000 per project			New Program with $10 million for construction of sewers and treatment plants in areas where septic tanks are failing.
Massachusetts	15% grant to municipalities receiving EPA grant; up to 90% if EPA eligible but no federal funds available.		No	No	
Michigan	5% to municipalities receiving EPA grant; nothing to those receiving no EPA grant.		No		
Minnesota	15% (up to 25% if "hardship case") to municipalities receiving EPA grant; in general nothing if not EPA eligible, but can get 25% if considered "health hazard."	no ceiling but low priority for state funds	No but is being considered		
Mississippi	No (see "loans")	Under PL 660 gave 25% "grants" to match EPA funds - in reality these were loans which are now available at 12.5% level for those receiving EPA grants.	No		
Missouri	15% for municipalities receiving EPA grant; nothing otherwise.		No		

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Table 1. (continued)

STATE	CONSTRUCTION GRANT DETAILS	CONSTRUCTION LOAN DETAILS	O&M PROGRAM DETAILS	BOND ASSISTANCE DETAILS	NOTES
Montana	No				
Nebraska	12 1/2% for municipalities receiving EPA grant; nothing otherwise.				
Nevada	No				
New Hampshire	20% to municipalities receiving EPA grant; paid in increments over life of bond issue - gives power over O&M.		No (but see O&M effects of grant)		
New Jersey	15% to municipalities receiving EPA grant; 25% if EPA eligible but no funds and are high enough on priority list.				Loans available for planning and design.
New Mexico	12 1/2% to municipalities with EPA grant; nothing if no EPA grant. There is another state program - although seldom used for treatment works - giving a treatment grant of $12,000 per project.		No But program along New York O&M program lines being considered to replace capital grant		
New York	12 1/2% to those municipalities which receive EPA grants; nothing for projects which are not EPA eligible.		33 1/3% of direct O&M costs paid by state		Comprehensive planning program - 100% state financed.
North Carolina	12 1/2% for municipalities with EPA grant; 25% for municipalities which are EPA eligible but receive no grant.		No		
North Dakota	No	But loans available from Bank of N.D. - generally no different but of assistance where credit rating is low	No		
Ohio	No	25% if get EPA grant; 100% if no EPA grant but satisfy Ohio EPA standards.	No		
Oklahoma	No		No		
Oregon	Nothing, in general, with EPA grant; maximum of 30% state grant for "hardship" communities.	For non-grant costs. Maximum loan is 70% of total	No		
Pennsylvania	No (see O&M)		"surrogate" O&M program with state paying 2% a year of initial construction costs which were not subsidized		
Rhode Island	15% for those receiving EPA grant; nothing without EPA grant.		No		
South Carolina	No	No	No		

Table 1. (continued)

STATE	CONSTRUCTION GRANT DETAILS	CONSTRUCTION LOAN DETAILS	O&M PROGRAM DETAILS	BOND ASSISTANCE DETAILS	NOTES
South Dakota	5% for those with EPA grant (although 25% theoretically possible); nothing without EPA grant.		No		
Tennessee	No (see "loans")	25% "grant" (to be paid back) if get EPA grant; nothing without EPA grant	No		
Texas	No	25% "grant" (to be paid back) with EPA grant; 100% without EPA grant and considering financial need.	No		
Utah	No				
Vermont	15% with EPA grants; 35% without EPA grants; if abates existing pollution - not for growth and development areas.	No			State pre-finances planning; loans are recovered.
Virginia	10% for municipalities which receive EPA grants; nothing without EPA grant.	No			
Washington	15% with EPA grant; nothing without EPA grant.	No	No		State gives 100% loans on pre-construction activities.
West Virginia	No		No But sometimes state participation in ownership and operation		
Wisconsin	Generally 5% with EPA grant, but 15% on advanced treatment costs. 25% if eligible but no EPA grant.		No		
Wyoming	No				

The construction grant programs are the most developed and interesting means for state financing of municipal wastewater treatment works. The range of programs which exists is presented in Table 2 (which is directly derived from Table 1). The numbers in each column indicate the number of state programs falling into each category.

The table illustrates that the most common form of state program is a construction grant program under which matching grants are awarded to municipalities receiving the 75 percent EPA grant under Public Law 92-500. In general, the grant is simply a "tack-on" to the EPA grant -- the same priority system and the same list of eligible items pertain. The awards under these programs vary from 5 to 25 percent. The situation concerning municipalities which are eligible for EPA grants, but which do not receive such grants (due to a combination of their position on the state priority system and the shortfall in federal allocations), varies widely. The most common state action is simply to exclude these municipalities from the state grant program (for example, Indiana). There are a number of states, however, in which the state will give a grant to municipalities in this category. These allocations range from 25 percent (the most common, Colorado, for instance) up to a maximum of 100 percent (which can be offered in Hawaii).

The most important and interesting deviation from this form is the Illinois program. Under this program the Illinois EPA allocates the federal allotment in accordance with EPA directives. The state funds are then used to offer 75 percent construction grants to those municipalities which are eligible for, but have not received, federal grants. No matching grants are given.

The second kind of state program is the construction loan program, which was introduced in a number of southern states (Louisiana, for instance) under Public Law 660. This program was officially called a "grant" since the state offered a 25 percent matching "grant" to enable the municipalities to get the full federal grant (of 50 percent). In fact, however, the municipalities were required to repay the "grant" to the state as they were loans in all respects (other than nominal). In most of the states where this kind of program was instituted, they continued to function although sometimes (Mississippi) at a reduced level; in other states (Louisiana) this program has, with the passage of Public Law 92-500, been abolished.

Table 2. STATE CONSTRUCTION GRANT PROGRAMS
NUMBER OF STATE PROGRAMS IN VARIOUS CATEGORIES

Level of State Grant for Municipalities Receiving an EPA Grant	Level of State Grant for Municipalities Eligible for, But Not Receiving, 75 Percent EPA Grant			
	None (0%)	Low (5-15%)	Medium (15-30%)	High (Over 30%)
None (0%)	21(1)	0	1(1)	1
Low (5-10%)	7	0	2	1
High (12.5-25%)	9(2,3)	0	4(2)	2(3)

(1) Oregon falls in two categories. There are a fraction of municipalities which are eligible for, but do not receive, an EPA grant and which, in addition, are not considered "hardship" communities, and therefore do not receive 30% state construction grants.

(2) Minnesota falls in two categories. The standard 15% state grant is raised for municipalities, not receiving EPA grants, which are considered to be health hazards in Minnesota.

(3) Maryland has a program for the issuing of 87.5% state grants to "urgent" cases which receive no federal grant.

The third program is operation and maintenance. The only operative operation and maintenance subsidy program is in New York. New York State pays one-third of operating expenses. This program has attracted the attention of at least one other state (New Mexico) where it is being considered as an alternative to the construction grant program. Operation and maintenance subsidy programs are also being considered in Washington and Minnesota.

Pennsylvania has a program under which the state annually pays the municipality 2 percent of the initial non-subsidized construction costs. While this may well be considered to be a construction grant, the state agency sees it as a program for assisting the municipalities in meeting their operation and maintenance costs. Pennsylvania does not use the apparent potential of the program to enforce satisfactory operation and maintenance. New Hampshire, by contrast, which pays construction grants (of 20 percent) in principal and interest installments each year over the life of the bond issue, recognizes the potential to use this financing mechanism to affect treatment facility operation.

LOCAL FINANCING PROGRAMS

During the fiscal year 1970-71 the federal government expended $776.9 million for water quality control activities. Of this, 89.7 percent was distributed to state and local governments through federal grant programs. The $493.2 million that flowed through EPA's grant program for constructing waste treatment facilities amounted to 70.7 percent of federal intergovernmental payments for water quality control.*

During the same period of time the nation's 48 largest cities spent $650.3 million on water quality control activities, 65 percent of which ($422.8 million) was capital outlay for new construction or improvement of existing sewage treatment plants. These cities raised $248.8 million -- 38 percent of their total water quality control expenditures -- from sewerage charges. The 32 counties out of the 58 with a population of 500,000 or more which reported expenditures on water quality control spent $160.8 million -- $123.5 million (76.8 percent) on capital outlay and $36.5 million for current operation.* The 38 largest SMSA's in the country spent $1.4 billion on water quality control of which $887 million (64.8 percent) went to capital outlay. Sewerage charges from local governments within these SMSA's returned $492.5 million or 35.2 percent of the total expenditures.

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* U.S. Department of Commerce, Bureau of the Census: Environmental Quality Control, Finances and Employment for Selected Large Governmental Units. Fiscal Year 1970-71, p. 3-5.

Traditional Methods of Financing

Local financing of municipal services has traditionally relied most heavily on property taxes. Although property taxes will continue to be the largest single source of local revenue, their general decline is prompting municipalities to seek other funding arrangements.+ For both state and local governments the share of revenues derived from federal sources is increasing (13.8 percent in 1960 to 16.7 percent in 1970); the share from state sources is growing (from 40.8 to 44.0 percent); and the share from local sources is declining (from 45.8 in 1960 to 39.3 percent in 1970).

With the decline in the use of property taxes, a cramped bond market, high interest rates and increasing costs, local governments have tried a variety of other revenue sources including special assessments, intermunicipal arrangements, revenue bonds, and, increasingly, a wide array of user or service charges levied for providing waste treatment service to a variety of customers.

Currently "Popular" Methods of Financing

User Charge Financing -- Financing the cost of operation and debt expenses through charges to those who use the service is not new.* In the 20 years between 1950 and 1970 municipal revenues from property taxes only tripled compared to a seven-fold increase in special charges revenue. In the 1972 Amendments to the Federal Water Pollution Control Act, the user charge became a required practice for any municipality seeking a federal grant for construction of waste treatment plants. Unfortunately such user charges represent one of the most regressive forms of revenue collection utilized by any level of government.+ Charges are also not deductible from federal income taxes, which places the loan squarely on the local charge payer's shoulders.‡

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* Many of the counties that reported no expenditures contain municipal governments or special districts that handle water quality control.

+ Local property taxes have been providing a decreasing proportion of state and local general revenues (from 31.3 percent in 1960 to 25.2 percent in 1970. Tax Foundation Inc., Research Publication (New Series No. 28), "The Financial Outlook for State and Local Government 1980," 1973, p. 82.

Special Assessments -- Special assessments have an even longer history than user charges as a means of financing public improvements on the basis of benefits. The special assessment has evolved as a tax used predominantly by municipalities and levied only on the area that would be demonstrably benefited by a proposed improvement. The levy is apportioned on the basis of benefits and the assessments can be made liens on the benefited property. The proceeds go to pay the cost of local improvements.

Special assessments are generally initiated by the municipal government or by petition of property owners. Property is assessed through an apportionment system based on benefits, usually according to frontage, zone, or area. Property is less frequently assessed on the basis of property valuation or the direct benefit a piece of property will receive. Municipalities more often use one of several plans to finance special assessments: special assessment bonds, special certificates of liens to the contractor, temporary loans from city funds, or advance payments from assessed property owners. In most cases assessments are not allowed to exceed the cost of the service and thus do not reflect any increased value of property which an improvement might bring.

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* Tax Foundation Inc., "The Financial Outlook for State and Local Government 1980," p. 6.

+ Public Interest Economics Center, "Who Bears the Cost of Pollution Control? The Impact on the Distribution of Income of Financing Federally Required Pollution Control," Report for Council on Environmental Quality, Washington, D.C., August 1973, pp. 25-26.

‡ Tax Foundation Inc., "The Financial Outlook for State and Local Government 1980," p. 6.

Revenue Bonds -- Use of revenue bonds in conjunction with user charges puts the sewage treatment service into a utility classification. These bonds are usually outside state-imposed debt limits and therefore are not subject to interest rate ceilings and do not require voter approval. There is precedent for treatment systems to become self-supporting through such financing.

Intermunicipal Arrangements to Provide Financing -- In a number of situations treatment facilities have provided the occasion for municipal cooperation. Communities which contribute their wastes to another community's facility pay a *pro rata* share of the capital cost of all facilities reserved for cost under their contract plus a *pro rata* share of all operating costs involved. In most cases the sewage service is provided just at cost. In other arrangements the contributors are charged on the basis of metered water use. These charges can resemble "suburban surcharges" over the cost to city users or they can be on a volume basis. Sometimes a large city will contract with a county which arranges sub-contracts with its cities. On occasion a city will provide area-wide services to surrounding municipalities and counties.

Another approach is a joint venture between two cities that collaborate to build a single treatment plant without creating a separate agency. One city then contracts with the other for service, paying a share based on a mutually agreed upon factor, such as volume rates, that can be adjusted to accommodate industrial wastes or changing flows.

Another type of cooperation is the special intermunicipal district which may be formed by a group of contiguous governments. Districts may be formed though state legislation and local ordinance or government action. Generally this type of district is financed from funds generated by each participating municipality through assessments on property within the district, sewer service charges, property taxes, sewer connection charges, general tax funds, and bond issues.

Finally, there are intermunicipal sewerage authorities that are independent and self-supporting. Such authorities are frequently almost entirely free of supervision by their parent government(s). Authorities may take on general and revenue bond obligations, set and charge user rates, borrow, and, in some cases, even tax.

Choosing a Finance Program

The choice of one method of financing waste treatment works over another appears to be a function of size of the municipality making the decision. U.S. Census information shows that cities under 500,000 depend on service charges for a larger share of their general income than do larger cities. These same cities also seem to use fewer alternative sources than the larger cities that impose more non-property taxes. Cities under 50,000 received 17 percent of their revenues from non-property taxes; cities of one million or more obtained 34 percent. Smaller cities are often prohibited from levying sales and income taxes by law, a practice which makes user charges all the more attractive. For all cities, charges are about equal to costs; but for the 43 largest cities they only provide 35 percent of costs. Some reasons for the lower use by large cities are the complexity of collection and administration on a large scale and the impact of service charges on the poor.

A similar relation between size and practice is found in the use of special assessments. Again cities of 500,000 or less have shown an increased use, but larger cities have shown a marked drop in such revenue. Cities of less than 25,000 increased their use of special assessments by 35.3 percent. Much of this trend may be due to the rapid spurt of growth that smaller sized cities in suburban areas are undergoing.

Selection of user charge schedule is also a function of municipal size. Small municipalities of 2,500 and under most often use the uniform flat rate because it is easy to administer. The modified flat rate (flat rate varied according to customer) and the water use formula are more often used by towns over 5,000. Few communities use plumbing fixture or water meter and sewer connections as a basis for rates.

SECTION 3

SELECTION CRITERIA AND FEATURES OF FINANCING ALTERNATIVES

INTRODUCTION

In the second section of this report the current federal program for aiding municipalities to finance the construction of wastewater treatment plants was described. In addition, examples of some of the state programs were presented. In this section four criteria -- effectiveness, efficiency, equity and feasibility -- for evaluating the current system will be described and some of the deficiencies these criteria suggest will be identified. Secondly, seven important features of possible alternative financing programs will be presented and discussed in terms of the criteria. The features include:

1. allotment formulas (for distribution of funds to states);
2. grant formulas (for distribution of funds to communities);
3. components of the wastewater systems eligible for assistance;
4. construction loans;
5. operation and maintenance grants;
6. planning standards to be imposed on communities seeking funds; and
7. the institution and type of plant performance standards once a treatment facility is in operation.

Two additional features of any financing scheme are the size of the grant to a municipality, i.e., percentage of costs to be subsidized, and the time pattern of the grant. Discussion of issues associated with grant size will appear in the context of allotment formulas, grant formulas, operation and maintenance grants, and construction loans, while those associated with timing will appear in the context of plant performance standards.

It is clear that there is a difference in the relative role of the above list of components.

Some of these items -- planning standards, program allotment formulas, and grant formulas -- would be components of any financing scheme while not explicitly specifying the type of assistance the federal government provides to municipalities -- the type of this assistance being specified by other components, e.g., construction and/or O&M grants and construction loans. Also it is obvious that all four criteria are not equally important in assessing each of the items. For example, effectiveness and feasibility would appear to be most important in discussing an O&M grant or plant performance standards while efficiency and equity would be more important when considering the amount of grants or an allotment formula.

The presentation in this section is limited to a discussion of criteria, deficiencies of current programs and features of alternative programs. The quantitative analysis appears in the next section of the report. The discussion in this section is not exhaustive or complete because some of the arguments for or against a particular feature of a financing program can be made more easily in quantitative terms. These arguments are presented in the subsequent section of the report.

CRITERIA

Effectiveness of a water pollution control program may be measured in terms of pollutant mass removed, sources brought into compliance, or length of river, lakeshore or ocean front brought to an acceptable water quality level. Depending on which of these definitions is used, effectiveness may be a trivial or important criterion in assessing a financing scheme. If the number of sources brought into compliance is the one used, then effectiveness is unimportant in the light of the 1972 Amendments. This is because the 1972 Amendments require municipalities to attain certain treatment levels by 1977 and 1983 and because the Congress has demonstrated a determination to appropriate sufficient monies to assist communities to meet these treatment levels. As discussed in Section 1, this study assumes the spirit of the 1972 Amendments will be met and that, with certain specific exceptions, nearly all municipalities will be in compliance with the law by 1977 (or within a few years of

1977) and by 1983, so that alternative financing programs will not differ as to effectiveness of pollution control. Exceptions to this generalization are:

1. simplification of the current system of construction grants might hasten the pre-1977 rate of compliance) and

2. fiscal bottlenecks at the federal level that could delay substantial compliance with the 1977 objectives by one or two years could be lessened by grant-reducing schemes (although any such schemes that were designed to alleviate federal bottlenecks would exacerbate bottlenecks at the local level).

If, however, effectiveness is to be measured in terms of pollutant mass removed or the length of river brought to an acceptable water quality level, then it is of some importance in assessing alternatives. In spite of the fact that plants must be built, whatever the method of financing, different grant programs will either encourage or discourage the proper operation of a treatment plant once it is constructed.

Thus, schemes providing a financial incentive to properly operate a treatment plant would be expected to have greater effectiveness than current schemes lacking a means of ensuring attainment of performance standards. Therefore, in this report effectiveness will only be relevant for evaluating alternatives with respect to attainment of performance standards.

Because there is no adequate measure of the benefits to be derived from the wastewater treatment requirements legislated by the 1972 Amendments, the criterion of efficiency* provides no standard for determining the amount of resources the federal government ought to commit to its grant program or the way in which these resources ought to be allocated. However, if concern is limited to treatment cost decisions, then the criterion of efficiency can be useful in identifying those alternatives which will allow a community to meet the requirements of the Act at least social cost. Some of the areas in which inefficiencies may arise are in the overcapitalization of a treatment facility, the improper selection of a treatment technology (e.g., conventional secondary treatment rather than some form of physical/chemical treatment), the rejection of a regional treatment scheme in favor of smaller local facilities, or the selection of a centralized collection and treatment system rather than individual on-site disposal.

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* In this context efficiency is defined in global terms. That is to say, a decision is efficient if resources are allocated in such a fashion that marginal social abatement benefits are equal to marginal social control costs.

Another criterion used in evaluating alternative financing schemes is the incidence of cost-bearing -- who pays for water pollution control. A more equitable program is defined as one which more nearly equalizes the financial burden among citizens where financial burden is a function of cost ultimately borne by a person and that person's ability to pay. Because a companion study is assessing impact of financing alternatives on individuals (spread in homogeneous communities across the land), this study focuses on community impact differences: specifically on differences in per capita costs from community to community and in local costs per dollar of family income from community to community.* Fiscal impacts of alternatives on federal, state and local budgets are estimated with such considerations in mind. It must be emphasized, however, that this study does not address the issue of local government financing and its impact on individuals nor even the aggregate effect of federal fiscal policy on individual income distribution or incidence of costs.

The notion of feasibility has at least two components in the context of financing programs -- administrative feasibility and political feasibility. In this report no attempt will be made to define either of these components for neither is easily defined except at the most superficial level. However, it is important to point out that feasibility is not ignored. The issues associated with administrative feasibility will be dealt with by identifying those features of a particular financing alternative which clearly will require that more resources be put into administering the program because of its complexity. Although there is no intention of dismissing the importance of political feasibility when considering the feasibility of a financing scheme, it is not a major issue in this report. This is the case because all the components of the alternative financing programs discussed in the report have their precedents in the legislative history of federal water policy or current and proposed state programs.

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* Dorfman, Nancy S. and Norman H. Jones, Jr., "Incidence of Alternative Financing Methods for the Municipal Treatment Facilities Program," prepared for Environmental Protection Agency by Public Interest Economics Center, Washington, D.C., June 14, 1974.

DEFICIENCIES IN EXISTING PROGRAMS

If the current federal financing program is assessed against the four criteria of effectiveness, efficiency, equity and feasibility, likely deficiencies can be pointed to on all four measures. Some of these shortcomings will be discussed below with suggestions for remedies. These and others will be elaborated in the following subsection "Features of Alternatives" and those which are particularly susceptible to quantitative analysis will also be discussed in Section 4.

On the effectiveness measure, as it has been defined above, the current federal financing program is sorely lacking. It contains no provisions to insure or encourage the proper operation of treatment facilities. The 75 percent construction grant makes the requirement of building a plant more palatable to communities than it otherwise might be, thus encouraging more rapid compliance, but the problems of operating the plant to achieve the highest levels of removal are ignored. Such a shortcoming may be very serious since in the absence of any incentive to operate and maintain a plant properly there may be ample incentive for a community to reduce current expenditures to the detriment of plant performance. Also, the present federal program does not encourage states to spend their water pollution control funds effectively. Currently most states which have some kind of program to aid communities in meeting the cost of treating their waste merely add to the capital grant offered by the federal government.*

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* There are some exceptions to this approach. For example, New York has an O&M subsidy program and Illinois has a policy of using its funds to increase the number of proposed plants on the priority list to receive grants.

Using the efficiency criterion suggests some additional deficiencies. Many of the critics of the current program argue that the 75 percent capital grant and the additional state grant, if there is a state program, results in a price distortion which may encourage over-investment in plant capital. If this were the case, it could prove to be a very ironic twist, since, as will be shown in Section 4, under some circumstances a capital grant of 75 percent may reduce the present value of total cost to the community by as little as 20 percent.

Also from the perspective of efficiency it is important to note that the present grant program excludes from its list of eligible items individual treatment units such as septic tanks. Such a situation may cause certain communities to buy a collection system and centralized treatment plant because, in spite of the fact that the plant and its collectors may be more expensive when counted in terms of total resources used, the price to the community will be lower because such a system is eligible for a grant.

For all practical purposes equity is ignored under the current grant formula. It is ignored because the financing program pays no attention to either inter-community differences in facility costs or the heterogeneous nature of communities in terms of such things as wealth measures. In Section 4 it will be shown that the fiscal burden placed upon communities with different characteristics can vary substantially.

The administrative feasibility of the program is a moot point. Clearly there are some bottlenecks, e.g., meeting the requirements of the permit system, and the regional offices of EPA and the state water quality offices feel as though they are overburdened, but there is no provision of the 1972 Amendments pertaining to the grant program which is, on the face of it, administratively infeasible. It is more likely that the commitment of funds to administer the program is inadequate.

Possibilities for improvement of the federal financing program include the following:

1. financing should be designed to provide an incentive to improved facility performance;

2. financing should reduce the resource allocation losses thought to be associated with current planning decisions --

losses arising from construction of oversized facilities or of choice of treatment processes which may be too capital-intensive;

3. financing should encourage states to spend their pollution control monies most effectively; and

4. financing should be designed to reduce currently large disparities in the burden of water pollution control among communities and individuals.

FEATURES OF ALTERNATIVES*

The presentation of alternatives will be organized around the seven features or components described above. Although each of the features may affect performance as measured according to more than one criterion, the discussion of effects will be limited to pointing out the impacts on the most important criterion (or criteria) associated with that feature.

Allotment and Grant Formulas

The allotment or state allocation formula is the basis on which federal authorizations (for whatever financing alternative) are distributed to the various states. The grant formula is the basis on which the size of the transfer payment to be given to the individual city or sewer district is determined.+

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* Appendix C presents the arguments for structuring financing programs with different characteristics in the broader context of fiscal federalism. The discussion in this section is specific to alternatives for financing wastewater works but there are analogies for the issues discussed in numerous financing programs. Some of these are discussed in Appendix C and a broad review of other programs influenced the discussion in this section.

+ In the rest of this discussion, for simplicity in exposition, the "city" will be used synonomously with the grant recipient, although in reality the institution building and operating a municipal treatment plant is often a sewer district or authority or some other institution created by one or more cities.

The present state allocation formula is based solely on needs. Prior to the 1972 Amendments the pollution control allotment was based primarily on population. However, population is often a poor surrogate for needs as shown in Table 3. The present grant formula is a simple 75 percent of the eligible capital costs and some associated planning and design costs. These eligible costs in the present program are detailed in Appendix B.

Grants may or may not have matching provisions. Matching provisions may be built into the grant formula or an incentive for matching grants may be built into the allotment formula. As discussed in Section 2, the current program requires 25 percent local or state monies on capital costs and 100 percent local or state monies for operation and maintenance costs. The alternatives discussed here all require local participation but only some require state participation.

The Allotment Formula -- The allotment formula could reasonably be based on three classes of measures: needs, current and/or past efforts, and revenue capacity, where one measure of revenue capacity is per capita income.

The ratio between the approved cost estimate of constructing all needed municipal plants in a state to the cost estimate for construction of all needed municipal plants in all the states is the current basis for determining needs. As stated previously, the total population was traditionally used as the basis for determining needs. Difficulties arise with this because different kinds of resources, in varying amounts, are required depending on specific area characteristics.

There are both efficiency and equity issues associated with these difficulties (issues also relevant to a discussion of the grant formula with its focus on the municipality rather than the state). If one assumes that municipalities select the alternative with lowest total resource costs, the existing need measure may be distorted in the relative distribution of eligible versus ineligible costs across states. For example, in highly urbanized states land costs (for biological or physical/chemical) may be a much higher percentage of total capital costs than in less urban states, and these land costs are not covered under the existing grant program. Furthermore, the definition of eligible costs limits examination of alternatives and thus precludes

TABLE 3.

State	Ranking by Total "Needs"(1)	Ranking by Needs Categories I+II+IVa(2)	Ranking by Population
Alabama	33	31	21
Alaska	44	41	51
Arizona	41	42	33
Arkansas	38	25	32
California	2	1	1
Colorado	34	30	29
Connecticut	10	25	24
Delaware	39	38	47
District of Columbia	13	48	41
Florida	8	6	9
Georgia	17	11	15
Hawaii	29	24	40
Idaho	47	45	43
Illinois	4	4	5
Indiana	15	18	11
Iowa	31	26	25
Kansas	25	28	28
Kentucky	16	16	23
Louisiana	32	34	20
Maine	37	33	38
Maryland	24	15	17
Massachusetts	9	12	10
Michigan	6	8	7
Minnesota	14	19	19
Mississippi	40	36	30
Missouri	18	10	13
Montana	48	47	45
Nebraska	35	43	35
Nevada	42	37	48
New Hampshire	30	27	42
New Jersey	5	3	8
New Mexico	46	46	37
New York	1	2	2
North Carolina	19	13	12
North Dakota	49	50	46
Ohio	7	5	6

TABLE 3. (continued)

State	Ranking by Total "Needs"(1)	Ranking by Needs Categories I+II+IVa(2)	Ranking by Population
Oklahoma	26	22	27
Oregon	28	32	31
Pennsylvania	3	7	3
Rhode Island	36	40	39
South Carolina	22	17	26
South Dakota	50	49	44
Tennessee	23	23	18
Texas	20	14	4
Utah	43	39	36
Vermont	45	44	49
Virginia	11	9	14
Washington	12	20	22
West Virginia	27	29	34
Wisconsin	21	21	16
Wyoming	51	51	50

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(1) See "Report to the Congress, Costs of Construction of Publicly-Owned Wastewater Treatment Works, 1973 'Needs' Survey," U.S. Environmental Protection Agency, revised November, 1973.

(2) These are the categories this study is explicitly examining.

selection of some alternatives that would minimize total resource costs. (Individual treatment systems are thus excluded from grant eligibility.)

The use of effort measures is an attractive addition to the allotment formula as an incentive for state programs to accelerate plant construction. The incentive can be structured on current effort measures, such as increasing the state allocation in states where monies are available to the city in lieu of, or prior to, availability of federal monies. Some states did construct treatment plants prior to receiving federal monies, monies promised by the 1966 legislation. For these states the equity argument is strong, and the inclusion of needs already met is equally forceful.

The allotment formula could contain a provision for needs already met -- for example, in proportion to the construction costs of those cities which have achieved secondary or best-practicable treatment in recent years.* This would necessitate defining a base year and estimating capital in place for that year.

Finally, a formula could be structured such that the state allotment would increase if the state funded (from its own monies) cities not high enough on the priority list to receive federal funding. This would encourage the short-term control of additional point sources for the same level of federal program dollar. The Illinois water pollution control program operates in this manner, presently, without the incentive. This could markedly affect the short-run difference in number of point sources controlled and mass of pollutant removed.

An alternative would be to provide an additional allocation if a state provided O&M subsidies, thus reducing the potential distortions associated with "capital only" grants, and hence impacting the equity and effectiveness criteria. The state of New York has a program of operation and maintenance grants and there is evidence to indicate that it is effective in improving plant performance.

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* If, for example, the allotment formula considered only needs and needs met, an alternative might be to allocate 80 percent of authorization on the basis of needs only and the remaining 20 percent incentive on needs met.

There are two important assumptions or beliefs implicit in the above discussion. The first is that any allotment formula should encourage states to assist in financing municipal wastewater treatment and the second is that this participation should be something other than a matching capital grants program. This reflects equity, efficiency, and effectiveness criteria. As the discussion in Section 4 will show, rarely does the present federal share represent even half of total treatment cost and for large numbers of cases it represents less than one-quarter of total costs. The requirements of the 1972 Amendments and national interests, as discussed in Section 2, argue on an equity basis against reducing the capital subsidy unless an O&M subsidy is also introduced. Increasing the capital subsidy beyond 75 percent, however, increases the "price effect" such that even use of other characteristics (such as planning standards) cannot protect against efficiency losses. This argues against incentives for state matching monies on capital. Also, as will be discussed below, an O&M subsidy may provide the leverage necessary to insure plant performance.

The Grant Formula -- The important criteria for judging grant formulas are equity and effectiveness. Inequities can be reduced explicitly with grant formulas. Thus the formula should reflect measures of per capita cost required to meet best-practicable treatment and should be dependent on per capita income and fiscal capacity. The crucial incentive issue is to induce proper operation and maintenance of existing and new plants and is associated with the question of operation and maintenance grants and performance standards. These are discussed later in this section.

The 1972 Amendments do not place the same financial burden on all communities. The water pollution control literature shows that financing programs have traditionally focused only on the differences of large versus small communities as reflected in varying per capita costs resulting from scale economies. However, it is also important to consider differences in revenue capacity among cities of the same size (or different sizes). Analysis in the following section (Section 4) indicates that municipalities are markedly non-homogenous in both the characteristics that influence:

(1) the requirements to meet the mandated treatment levels; and (2) the financing of these requirements. Although previous federal grant formulas in water pollution control have not explicitly had income and/or fiscal capacity variables among their provisions, there are several examples of such formulations in numerous other federal grant programs. The particular national objective orientation of the Amendments as discussed in Section 2 and the significant evidence of the distributional consequence presented quantitatively in Section 4 suggest designing grant formulas to approach a more equitable distribution of local costs.

This suggestion arises since many other federal programs have made some allowances in either the allotment and/or grant formulas for differences in income and/or fiscal capacity as well as for differences in needs or costs. These programs have been both for public facility construction and for the provision of services. There is considerable precedent for relatively complex formulas being utilized to achieve a mixture of objectives. The complicated revenue-sharing formulas are obvious examples of such approaches.* The grant formula could be constructed to

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* For a discussion of the general revenue-sharing formulas, see "Questions and Answers Relating to Revenue-Sharing," State Government: The Journal of State Affairs, Vol. 46, Winter 1973, No. 1, pp. 30-31. Additional examples are the following:

Title I of the ESEA of 1965 -- grants to local school districts (through state agency)

$$A_{ij} = P_j \frac{E_i}{2} \text{ or } P_j \frac{E_{us}}{2} \quad \text{whichever is larger}$$

where A_{ij} = magnitude of grant to jth school district in the ith state

P_j = the population of "deprived" children in the jth district (basically from families with incomes below $3,000)

E_i = average per child expenditure for elementary and secondary education in ith state

E_{us} = average per child expenditure in U.S.

incorporate both total costs and per capita costs as measures of needs and potential distributional inequities and income (or another surrogate) as a measure of fiscal capacity.*

(footnote continued from previous page)

This formula provides partial correction for cost differences and tends to define requirements for programs for deprived children in terms of the standard of support for education in state or nation.

Another example is in the area of Child Welfare Services. (A similar form is used for grants to Community Mental Health Centers.) The allocations are determined by a formula of the form:

$$A_i = a_0 + a_1 \frac{P_i(1.0 - 0.5\ y_i/y)}{\Sigma_j P_j(1.0 - 0.5)\ y_i/y)}$$

where A_i = magnitude of grant to ith state

a_0 = small constant to cover administrative expenses

P_i = number of children under 21 in the ith state

P_j = number of children under 21 in jth state (all other states)

y_i = average per capita income in ith state

y = average per capita income in U.S.

In addition, the matching ratio for each state (F_i) is a function of the per capita income in that state.

$$F_i = 1.0 - 0.5\ (y_i/y)$$

* If, for example, as is suggested in this report, the grants become annual transfer payments on both capital and O&M expenditures, an attractive grant formula would be of the form

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$$G_i = f_1 \text{ (total annual costs)} + f_2 \text{ (per capita costs)} + f_3 \text{ (fiscal capacity)}$$

where G_i is the annual grant to the ith community and f_1, f_2, and f_3 are functions. A possible "linear" form would be the following:

$$G_i = \alpha C_i + \beta \frac{c_i^*}{\hat{c} - \bar{c}} C + \gamma \frac{\xi_i^*}{\bar{\xi} - \hat{\xi}} C_i \ ,$$

where C_i = total annual costs for community i

c_i = per capita annual costs for community i

ξ_i = per capita income for community i

$\bar{c}$ = average national per capita costs

$\bar{\xi}$ = average national per capita income

$\hat{c}$ = the highest expected per capita community costs
($c_i \leq \hat{c}$ for all i)

$\hat{\xi}$ = the lowest expected per capita community income
($\xi \geq \hat{\xi}$ for all i)

c_i^* = the "more than average" per capita costs for community i

$= 0$ if $c_i \leq \bar{c}$,

$= c_i - \bar{c}$ if $c_i > \bar{c}$

ξ_i^* = the "less than average" per capita income for community i

$= 0$ if $\xi_i \geq \bar{\xi}$,

$= \bar{\xi} - \xi_i$ if $\xi_i < \bar{\xi}$

ELIGIBLE ITEMS AND A CONSIDERATION OF THE TOTAL WASTEWATER SYSTEM

Formally, this study is restricted to considerations of wastewater treatment plants -- nominally this is further restricted to "sanitary" wastes as opposed to storm drainage and combined wastes. It is true that wastewater treatment plants traditionally have been designed to accept and treat wastewater, whatever its quality and quantity, as it arrives at the plant. In order to gain some perspective on possibly useful modifications of this traditional approach and their relationship to financing alternatives, it is appropriate to digress briefly from the assigned task and consider some of the early history of sewerage practices and some important features of the total wastewater system.

Sewers have been built in the United States since the 17th Century. Initially sewers were laid as a result of private enterprise: a householder or group of householders would build whatever type of structure they wished -- on the

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α = a fixed fraction of cost to be granted irrespective of community costs and/or income -- perhaps $\alpha = .25$,

β = a maximum additional fraction of costs to be granted dependent on excess of the community per capita costs,

$.2 \leq \beta \leq .3$, and

γ = a maximum additional fraction of costs to be granted dependent on the extent to which the community fiscal capacity (as measured by average income) falls below the national average -- $.2 \leq \gamma \leq .3$.

Such a grant formula provides for a minimum (α) fraction of costs to be borne by the federal government, and the total fraction to increase directly with per capita costs in excess of the average and with income less than the average. Numerous non-linear variations of this approach could be suggested -- for example, a multiplicative additional factor could be a joint function of both excess per capita costs and income.

shortest line to the receiving body of water.* Since they owned the drain, all newcomers would have to "buy in" -- or build their own. Residents of Boston, for example, proceeded in this manner until 150 years ago when the city began to provide such a basic service.

When cities began to take over the sewer systems, they merely added on to what was already in place. As a result, many systems are old (very old) in a large proportion of the overall drainage network. Also, they were often built with little attention to performance characteristics that affected their potential contribution to pollution containments. Preeminently, performance characteristics were thought of in hydraulic terms, with deposition control, for example, assuming a secondary position. In addition, few records were kept of what was built, much less how the system may have been modified over the decades, or what its present condition may be. One consequence of these circumstances is that such systems are not often very watertight. Wastewater can leak out under some conditions leading to noisome conditions in basements and the like, and possibly to hazardous cross-connections with the system that distributes fresh water. Also, groundwaters can leak into the drainage systems.

The normal practice for designing a plant is to take such infiltration as a given parameter that will not be modified. For example, a competent consulting engineering firm recently designed an interceptor for a large city in the northeastern part of the United States based, in part, on assumed infiltration rates as high as 4,000 gpd/acre. Such an "infiltration" rate would exceed a mean annual rainfall of 53 inches per year. To translate this into people, a density of 20 persons per acre and a per capita wastewater discharge of 100 gallons per day would imply a dry weather flow of 2,000 gallons per acre per day. The design infiltration rate exceeds this flow by 100 percent. In this case tidegate repair and other means of restoring the integrity of the collection system should have been considered before specifying new capacity of interceptors, pumping stations and treatment plants.

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* Some were as simple as ditches unlined on the bottom with unmortared bricks for sidewalls and wooden planks for tops.

Additionally, such seemingly innocuous practices as the connection of roof drains may significantly dilute the dry weather flow during storm periods, with the concomitant result that the excessive increases in hydraulic flows causes a considerable decrease in the capacity of the treatment plant to remove pollutants. Undermaintenance of the collection system is another problem. For example, prior to the installation of a new operating and control program in the drainage system of Minneapolis-St. Paul -- a modern updating that includes telemetering and telecontrol -- the existing system was "tuned up" to the original operating specifications. That is, hydraulic control works, such as leaping weirs and other control structures, were adjusted or replaced as needed. Reportedly, the increase in suspended solids loadings, and those of other pollutants, received at the plant during runoff periods were substantially increased, thus reducing the volume of pollutants that would have been dumped directly in the Mississippi River.

In each of these cases it is possible to see alternative policies for maintenance, operation and regulation which would either reduce or substantially even out the hydraulic loading on the waste treatment facilities. Even though old, the faults in many systems are minor. For example, a recent inspection of a portion of the Boston system showed that the replacement of a few bricks at a control weir decreased the intrusion of sea water. The effect was to reduce the treatment plant load by several tens of thousands of population equivalents. Such faults can be discovered by more thorough inspection and documentation of existing systems.

In some cases elaborate schemes, such as television inspection and recording are worthwhile. In many others, simply going and looking, backed up by elementary physical and chemical analyses, will expose many minor shortcomings, easily correctable, that will substantially improve system effectiveness. In still other cases, policies that result in the disconnection of downspouts from sanitary sewerage systems have been found to be remarkably effective alternatives to treatment plant expansions. There can be no doubt that improved maintenance and operation of collection systems could increase the effectiveness of the existing investments without requiring greatly increased investments in waste treatment facilities, the additional capacity of which may only be used for a few hours a year.

Another issue associated with the whole system and the potential distorting effects of grants for only part of the system concerns individual on-site treatment (e.g., septic tanks) versus collection and plant treatment. Humm compared the costs of conventional collection, treatment and surface disposal with those of on-lot, sub-surface treatment and disposal for 38 small (population under 1,000) Vermont communities that had at that time preliminary or final designs for central treatment plants.* He estimates the additional resource cost for centralized systems compared with individual treatment to be $8 million. The individual treatment alternative, however, is not being selected because of ineligibility for federal grants.

Clearly, a grant program which is not designed to account for the issues raised in the context of a total wastewater collection and treatment system is going to encourage inefficient capital decisions and ineffective operation of a system. Constructing a new treatment plant to be attached to an antiquated collection system with numerous "illegal" storm connections and little integrity is bound to lead to an inefficient design. The plant will have to be built to accommodate significant infiltration, increasing need capacity by as much as 100 percent. In addition, the effective operation of the plant would depend on the hydrograph of wastewater flows particularly as it was affected by the "illegal" connections.

The implications of excluding individual treatment units from receiving grants are obvious. Many small communities, acting as cost minimizers, will select the alternative for which they pay the least regardless of the total resource costs.

LOAN PROGRAMS

Systems can be financed by a grant program, a loan program, or a combination of the two. The present federal program consists of grants augmented in some cases by state loan programs. Pure loan programs are more limited than grant programs in the percentage of costs they can assume. The Amendments authorize the establishment of an Environmental Financing Authority whose purpose is to assure that:

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* Humm, W. R., "Municipal Ownership of Individual Treatment Systems," in Proceedings of Sewage Treatment in Small Towns and Rural Areas, Conference at Dartmouth College, Hanover, New Hampshire, March, 1971.

> ...inability to borrow necessary funds on reasonable terms does not prevent any State or local public body from carrying out any project for construction of waste treatment works determined eligible for assistance...*

The structure of the Environmental Financing Authority is currently under development.

Unless a loan is complemented with some grant aspects, it cannot contribute the significant cost share which is available in the current grant program. As the examples in the next section+ indicate, in many cases the annual capital related costs (interest and capital payment) represent less than 60 percent of total (capital associated and annual O&M costs). Even if an interest-free loan is provided, which reduces the annual capital costs by approximately 50 percent, the percentage of total annual costs this reduction represents is usually less than 30 percent.

However, the periodic transfer payment feature of some loan programs is attractive for two reasons. First they spread the required federal expenditures over an extended period of time. Second they might be used to facilitate the enforcement of performance standards. Such standards are very useful for meeting the effectiveness criterion, as discussed elsewhere in this section.

One example of the use of annual transfer payments are the federal programs to aid local public housing authorities in covering construction costs. In addition, since 1969 some of the operating and maintenance costs of local authorities have been covered by the federal government. The grants to cover the construction costs are of the form of annual payments to the local housing authority to cover interest and amortization.* Public housing authority bonds to cover construction costs are issued by the federal government in the name of the local housing authority, and are tax-free under the federal tax code. In the case of sewage treatment capital costs, the federal government might use the potential withholding of interest and amortization payments to local governments as an incentive for them to meet the performance standards. In such a case the bonds would have to be issued by the local authority. The question remains as to how the market would evaluate the uncertainty associated with the conditional backing of the federal government. Public housing authority bonds are considered to be about as secure as other federal obligations, which means they carry interest rates considerably lower than those of municipal bonds.

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* Public Law 92-500, 92nd Congress, S. 2770, October 18, 1972; Environmental Financing, Section 12(c), p. 85.

+ These cases utilize a 30-year capital amortization period with 6 percent interest charges.

OPERATION AND MAINTENANCE GRANTS

The present federal program covers essentially capital items only. New York State has the only state operation and maintenance grant program. The alternatives considered in this report examine both capital and operation and maintenance programs.

It can be argued that because operation and maintenance costs are not subsidized, municipal grant recipients are biased towards the selection of capital-intensive alternatives. A strong advantage of a financing program which supports both capital and O&M costs is the possibility of equalizing local share ratios of these costs and, hence, eliminating the bias. Theoretically, if there is no differential grant on capital or operating costs, then municipalities acting as cost minimizers will select the most efficient treatment alternative (from a national and local viewpoint).*

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* Before construction begins, the Department of Housing and Urban Development enters into an annual contributions contract covering interest and amortization on long-term bonds issued by the local housing authority after construction is completed. This agreement cannot exceed forty years. This is discussed in Aaron, Henry J., Shelter and Subsidies: Who Benefits from Federal Housing Policies? The Brookings Institution, Washington, D.C., 1972, pp. 112-113.

However, the bias towards selection of capital-intensive alternatives is not simply one of "price effect" stemming from differential subsidies. Two other issues are significant. The first is the limited evidence that municipalities do not weigh capital and O&M dollars equally. The result is that municipal budgeting process decisions favor capital-intensive programs. The second issue is whether all potential treatment alternatives receive adequate examination or whether the present incentive built into the engineering fee structure and professional inertia result in capital-intensive designs.

Perhaps more important, operation and maintenance grants may be attractive because they are not lump sum payments but continuing transfers which can be made to depend on the performance of treatment plants. New York State has found that its O&M grant program is an effective and flexible mechanism for improving plant performance and insuring compliance with state regulations.+

PLANNING AND PERFORMANCE STANDARDS

Financing alternatives may be linked to a variety of planning and performance criteria. The current federal program requires approved facilities planning, but the amount of the grant is not dependent on type of planning.

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* We have examined the distorting influence of this grant in recent studies of market mechanisms for control of pollution, "Effluent Charges: Is the Price Right?" Environmental Protection Agency, Washington, D.C., September, 1973. Utilizing recently developed cost data for the Cleveland-Akron area on biological, physical, chemical and land-oriented treatment schemes, Raymond studied the potential efficiency losses stemming from this bias, "Impact of Federal Financing Provisions on the Federal Water Pollution Control Act Amendments of 1972," unpublished manuscript, Center for Urban Regionalism, Kent State University.

+ Meta Systems Inc., "New York State Aid for Operation and Maintenance of Sewage Treatment PLants: Implications for Federal Policy," for Environmental Protection Agency, Washington, D.C., November, 1973.

Alternatives could either make grant size a function of the type of planning or merely make grant approval dependent on certain planning having been done within prescribed guidelines. For example, grant approval could be conditional on facilities planning having been integrated with comprehensive land use planning.

A list of general characteristics of performance criteria includes the following:

- enactment and enforcement of a sewer use ordinance;
- qualified operators, adequate in number;
- adequate laboratory testing capabilities, under effective sampling and analytical supervision;
- adequate infiltration study, with a satisfactory program for abatement, updated as necessary;
- monthly operating reports;
- audited accounting records of costs;
- acceptable plant performance in terms of:

  good housekeeping practices,

  compliance with permit to discharge,

  safety program,

  upgrading program,

  production, within practical limits, of the degree of treatment which the process is designed to produce under conditions of design flow and loading, and

  relationship to stream standards;
- adequate reporting of the bypass or overflow incidents; and
- annual engineering reporting on collection and treatment plant performance, with recommendations (prepared

by qualified in-house engineering staff or outside consultant).*

Planning Standards and Cost Estimating

In the past municipalities and their consultants did not fully examine a range of treatment alternatives, and there was little pressure either from state or regional EPA authorities to do so. The new guidelines for facilities planning are explicit in discussing the need for detailed analysis of treatment alternatives. If these guidelines are stiffened and if appropriate regional review is initiated, this can serve to force examination of all viable alternatives and selection of efficient and effective, rather than local, least-cost alternatives.

Such review of the adequacy of the waste treatment plans can be facilitated by the development of regionally (or state) adjusted cost standards for various treatment alternatives. However, the development of adequate review standards dependent on costs will be a difficult task given the great variability in design practice and cost estimating procedures across the nation.

There have been some quantitative empirical studies of variability in design practice. One such study, conducted in Wisconsin during 1967, was concerned with the design practices for storm drainage in use in the state.+ Thirty-two cities were surveyed. The median (1966) population was 30,000 and the range was from 7,500 to 770,000 and the areas varied in size from 9.8 square miles to 96.5 square miles. The survey included a questionnaire on sewerage system problems, sewage treatment plant experience after rain or snowmelt, and the like.

In addition, each city was presented with a well-defined (albeit hypothetical) storm drainage design problem for a

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* Meta Systems Inc., "New York State Aid for Operation and Maintenance of Sewage Treatment Plants: Implications for Federal Policy."

+ Ardis, C. V., Dueker, K. J., and A. T. Lenz, "Storm Drainage Practices of Thirty-Two Cities," Journal of Hydraulics Division, ASCE, 95 (HY1), 383-408 (1969).

15-acre residential area. The engineering calculations involved in the study were not trivial (at least one professional man-day was required in each city). Many differences in practices were noted in the detailed evaluation. Some of the differences could be explained in terms of local attitudes toward urban flooding, and others to possible use of outmoded technical analysis. For our purposes, however, it is sufficient to note that the total costs estimated for the designs presented by the engineering departments ranged from $7,000 to almost $70,000. Although the variability in the design and cost estimate of treatment works may not be as extreme, statistical studies of costs of existing treatment plants which have been undertaken show a wide range of costs.*

There appear to be two alternatives for developing cost review procedures. One approach is engineering design review which is based on detailed itemized cost studies. The other is the standardized cost function approach which relies on the development of average cost estimates functionally dependent on standard design variables such as flow and concentration. Although the adoption of the former procedure probably would lead to more efficient designs, it implies a commitment of substantial resources to the administrative task of review. The latter approach, while administratively less costly, would also be less reliable. A review of the current literature on cost estimating indicates that it would be difficult to identify errors of less than 20 to 30 percent. Assuming that some form of the standardized cost function is to be utilized, this argues strongly for limiting the "price effect" of the capital grant. At over 75 percent the incentive for overexpenditure on capital from the local perspective is high and the ability to detect it is limited.

Continuing Performance Standards and the Leverage on Operation and Maintenance -- The financing alternatives could also be keyed to a set of continuing performance standards where the grant is forthcoming only if performance standards are met. Such a program provides leverage to induce improved operation and maintenance of treatment systems. There would be no lump sum transfer to the municipality, rather payments would be made on an annual basis depending on plant performance. It could be built into either loan or grant programs, with some of the interest and/or capital amortization grant being subject to performance standards. The present federal program does not include this characteristic.

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* Shah, Kanti and George Reid, "Techniques for Estimating Construction Costs of Waste Treatment Plants," J. Water Pollution Control Federation, 42, No. 5, Part 1, May, 1970.

An adequate financing program for water quality management will include provisions that assure the continuing performance -- to some specified levels -- of the investment in collection and treatment systems. Unfortunately, the prevailing attitude has been to emphasize the planning, design and construction of such works, but not their performance. Informal surveys of hundreds of plants indicate many instances of poor housekeeping practices. In such cases, improvements of the order of 5 to 15 percent in removal efficiencies can be expected at negligible increases in operation and maintenance costs.*

Effecting Changes in Operation and Maintenance: Some Examples -- Table 4 on the following page presents common operation and maintenance problems.+ It lists the

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* We feel confident in this assertion because our involvement in this area has been significant over a long period of time. Specifically important are: the observations and experience at numerous treatment plants, primarily by two of our principals, Joseph J. Harrington and Harold A. Thomas, Jr.; the earlier research on the design and operation theory for treatment plants by Thomas, and recently by William Pisano and Joseph J. Harrington; the numerous discussion of the issues with other professionals; and, finally, the additional experience resulting from our recent study of the New York State O&M program.

+ Other examples could have been added such as gross operator negligence (e.g., utilizing only some of the primary tanks or shutting off aerators), or the more subtle issue of inadequate monitoring of a sensitive process (e.g., allowing digestion to go "sour").

Table 4. IMPLICATIONS OF OPERATION AND MAINTENANCE PROBLEMS AND SOME SOLUTIONS

Operation or Maintenance Problem	Implication	Solution
Treatment Plant		
Wrong mix liquor SS concentration	Lower (than design) organic removal in activated sludge system	Measure more frequently, change recirculation and cell residence time
Uncalibrated flow meters	Improper chemical dosage and poor performance in secondary clarifiers	Calibrate meters, adjust dosage rates
Lack of rotameter	Inadequate or differential aeration in some tanks -- poor performance (lower DO poor settling floc)	Install rotameter, split air measurement and adjust for each tank
Infrequent sludge cleaning in primary units	Lifting and flotation resulting from anaerobic gas discharge decreases primary removal levels	Adjust removal frequency with loading rate
Poorly maintained or cleaned effluent weirs	Non-linear hydraulic effects leading to lower removals	Maintain and clean regularly
Clogged manifolds on trickling filter	Uneven loading decreases net effective capacity reducing removals	Clean manifolds regularly
Collection System		
Inadequate infiltration control	Hydraulic overload or too-diluted a solution for trickling filter -- removals reduced	Institute a program to control infiltration
Inadequate cleaning of interceptors	Solids bypass plant during scouring high flows	Clean interceptor regularly

implications of these problems and suggests solutions. The purpose is to illustrate how leverage can be applied to O&M problems and how changes might result.

Some of the problems cited in the table directly affect such parameters as effective capacity and loading intensity. The empirical relationships which have been developed for treatment plant removal efficiencies as a function of these and other parameters show that manipulation of these parameters by dealing with the problems of the type cited in Table 4 would lead to the 5 to 15 percent increase in removal efficiency referred to above. The process of effecting these changes, of course, would be one of gradual change, but these improvements are probably possible in more than half of the plants in this country.

The solutions given in the table are ones that would be induced by a performance standards program that includes monitoring, operating guidelines, and fiscal incentives. None of the solutions require significant plant changes. Some are merely housekeeping types of changes; most require more regular operation with a trained person; some imply additional costs (men, chemicals, power). All result in better plant performance. In addition to ameliorating old problems, plant performance standards would insure that similar problems did not occur in new plants.

CONCLUSIONS

The discussion and arguments presented in this section, while not leading to the design of a financing program, do suggest what features of any scheme will provide some control of program performance as measured by the criteria. Efficiency can be affected by altering the design of allotment and grant formulas, by improving planning standards, and by modifying the list of eligible wastewater system components. Effectiveness can be increased by initiating an O&M grant program and by developing and implementing plant performance standards. Insuring a more equitable distribution of the cost burden can be accomplished by modifying the grant formulas. None of the suggestions made in this section are infeasible from either an administrative or political perspective. On the other hand, it is obvious that any financing program designed to perform well on the three other criteria will be a program requiring considerable resources for administration.

SECTION 4

QUANTITATIVE ANALYSIS OF FINANCING ALTERNATIVES

INTRODUCTION

The previous section of the report discussed alternative grant programs that the federal government might consider to finance a portion of the expenditures for wastewater treatment required by the 1972 Amendments. The earlier discussion suggests that alternative grant programs might be appropriately characterized by seven features. In this section a limited number of alternatives are quantitatively examined. These alternatives are associated most explicitly with the grant formula. They vary in three characteristics: size and time pattern of construction grant and size of operation and maintenance grant. The discussion in the previous section also suggests that the fiscal impact on municipalities and the distributional impact on individuals will vary greatly depending on the variables of population, revenue base, current budget, family income, growth rate, condition of existing sewerage system, and industrial component of waste flow. In this section the implications of these differences for local fiscal impact and for equity are identified and related to alternative financing programs.

First, the results of a community classification scheme are discussed: (1) to illustrate the heterogeneity of communities in terms of population, growth rate, percent low income, per capita revenue, per capita debt, median family income, percent sewered, existing treatment capacity and industrial share; (2) to identify significant relationships between these community characteristics; and (3) to provide a basis for evaluating municipal model results.* Second, a model of municipal decisionmaking with respect to wastewater treatment plant construction time and design capacity is employed in order to estimate how alternative financing schemes and community characteristics affect efficient resource allocation measures of community and federal financial impact and the equitable sharing of the costs of water pollution control. Third, the 1973 Survey of Needs is utilized to estimate the state and national fiscal impacts of alternative financing schemes. These three areas of analysis, together with the qualitative analysis in Section 3, allow the drawing of conclusions and recommendations regarding alternative financing programs.

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* Details of the community classification scheme are presented in Appendix E.

THE COMMUNITY CLASSIFICATION SCHEME

The classification scheme relates to community population size such characteristics as population growth rate, median family income, per capita revenue, per capita debt, percentage of population sewered, existing treatment capacity, and percentage of industrial sewer flow. The data used in the scheme are taken from the computer tapes of the City and County Data Book (Census Bureau) and the 1973 Survey of Needs (EPA). The classification methodology adopted is based on the hypothesis that such characteristics as growth rate, per capita revenue, or percentage of the population sewered vary with population size and that in addition for communities in a given population size group these characteristics also vary. To test this hypothesis, simple contingency table analysis is performed on the following set of variables:

a. Population (1970) vs. Growth Rate (1960-1970);

b. Population vs. Percent Low Income;

c. Population vs. Per Capita Expenditures;

d. Population vs. Per Capita Debt;

e. Population vs. Median Family Income;

f. Population vs. Per Capita Revenue;

g. Population vs. Percent of Families with Income less than X Dollars;

h. Population vs. Percent Sewered;

i. Population vs. Excess Treatment Capacity; and

j. Population vs. Industrial Share.

The contingency tables* display, in a discrete format, the relationship between the independent variable (in all cases population) and a characteristic or dependent variable, e.g., growth rate. Each row of a table represents a range of city sizes and each column a range of values for a particular dependent variable. For example, in Table 5 all the entries in the second row are cities with populations between 25,000 and 37,500. The sixth column in that table contains all entries for cities with a growth rate between zero percent and 5 percent. The last two rows of the table, labeled "PERCENT" and "TOTAL," are the marginal distribution and total number of entries in each growth rate category. The right most column of the table, labeled "TOTAL," contains the marginal distribution and number of cities in each population group.

The cells in a table contain four numbers:

1. the percent of row totals, i.e., the percentage of cities in a given size range which fall into a given dependent variable category;
2. percent of sub-table total, i.e., the percent of all cities in the sample which fall into a given dependent variable category;

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* Contingency tables are constructed from sets of discrete categories of two variables. Using a contingency table, it can be determined whether or not a relationship exists between the variables. The test is based upon the hypothesis that the pattern of the entries in the cells of a contingency table are functions of the discrete marginal distributions of the two variables, i.e., that the variables are independent. (The marginal distribution of a variable which takes on discrete values is the frequency function of that variable independent of other variables.) The statistic most often used in this test is the Chi-square statistic. If the significance of the Chi-square statistic is of the order of .01, then it is reasonable to reject the hypothesis that the variables are independent. The rejection of this hypothesis implies that the variables do possess some sort of relationship. An examination of the table usually leads to some understanding of the nature of this relationship.

Table 5.

VAR(4)
GROWTH RATE

VAR(9) POPULATION	>20% DEC 1	>15% DEC 2	>10% DEC 3	> 5% DEC 4	0-5% DEC* 5	0-5% INC 6	<10% INC 7	<15% INC 8	<20% INC 9	>20% INC** 10	TOTAL
<25000 1	0.0 0	0.0 0	0.0 0	0.0 0	0.3 0	100.0% 0.1% 0.6 1	0.1 0	0.0 0	0.0 0	0.0 0	0.1% 1
<37500 2	0.0 0	0.0 0	0.0 0	0.0 0	21.8% 7.8% 77.0 64	57.5% 20.5% 164.6 169	12.6% 4.5% 30.3 37	4.8% 1.7% 12.5 14	1.0% 0.4% 4.3 3	2.4% 0.8% 5.3 7	35.6% 294
<50000 3	0.0 0	0.0 0	0.0 0	0.0 0	20.1% 3.8% 40.3 31	66.9% 12.5% 86.2 103	6.5% 1.2% 15.9 10	2.6% 0.5% 6.5 4	2.6% 0.5% 2.2 4	1.3% 0.2% 2.6 2	18.7% 154
<75000 4	0.0 0	0.0 0	0.0 0	0.0 0	26.0% 4.8% 40.3 40	52.6% 9.8% 86.2 81	12.3% 2.3% 15.9 19	6.5% 1.2% 6.5 10	0.6% 0.1% 2.2 1	1.9% 0.4% 2.6 3	18.7% 154
<100000 5	0.0 0	0.0 0	0.0 0	0.0 0	31.4% 2.7% 18.3 22	52.9% 4.5% 39.2 37	7.1% 0.6% 7.2 5	5.7% 0.5% 3.0 4	2.9% 0.2% 1.0 2	1.3 0	8.5% 70
<150000 6	0.0 0	0.0 0	0.0 0	0.0 0	34.9% 2.7% 16.5 22	44.4% 3.4% 35.3 28	15.9% 1.2% 6.5 10	1.6% 0.1% 2.7 1	0.9 0	3.2% 0.2% 1.1 2	7.6% 63
>150000 7	0.0 0	0.0 0	0.0 0	0.0 0	41.6% 4.5% 23.3 37	48.3% 5.2% 49.8 43	4.5% 0.5% 9.2 4	2.2% 0.2% 3.8 2	2.2% 0.2% 1.3 2	1.1% 0.1% 1.6 1	10.8% 89
PERCENT	0.0%	0.0%	0.0%	0.0%	26.2%	56.0%	10.3%	4.2%	1.5%	1.8%	100.0%
TOTAL	0	0	0	0	216	462	85	35	12	15	825

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
PERCENT OF SUB-TABLE TOTAL
EXPECTED VALUES

CHI-SQUARE 44.6164 SIGNIFICANT AT .044 WITH 30 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE 825
NUMBER OF UNITS OMITTED DUE TO BLANKS 19

* DECREASE
**INCREASE

3. expected values, i.e., the number of cities in a given size range which might be expected to fall in a certain dependent variable category if city size and the dependent variable were, in fact, independent; and

4. the number of cell entries, i.e., the number of cities in the sample in a given size range and a given dependent variable category.

For example, in Table 5 the cell delineated by the second row and the sixth column contains these numbers for cities between 25,000 and 37,500 with growth rates between zero percent and 5 percent. An examination of this cell indicates that 57.5 percent of the cities in this size range have growth rates between zero and 5 percent. 20.5 percent of all cities in the sample are in this size range and have growth rates within this range. In addition, if size and growth rate were independent, 104.6 cities would be expected to fall into this cell, whereas the actual number of cell entries is 169 or more than expected.

The other important numbers in the tables are the Chi-square statistic, level of significance and degrees of freedom. These appear in the row labeled, "CHI-SQUARE." In Table 5, for example, the Chi-square statistic has a value of 44.616 with a significance of .044 for 30 degrees of freedom.* In other words, if growth rate and population size are independent, the probability of obtaining a Chi-square value of 44.616 with 30 degrees of freedom is .044.

In the interpretation of the contingency tables, the first number at which to look is the significance of the Chi-square statistic. If it is less than .01, it is reasonable to assume that there is some relationship between population and the dependent variable. If, on the basis of significance, a relationship is found, then examination of the expected values and the actual cell entries suggests what the nature of that relationship may be. For example, if the cells in the northwest portion and the southeast portion of the contingency table showed positive differences between the actual cell entry and the expected cell values and the cells in the northeast and southwest showed negative differences, then it could be said that there was a positive relationship between the independent variable and dependent variable.

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* The degrees of freedom in a contingency table of r rows and c columns is equal to (r-1)(c-1). In Table 5, for example, there are 7 rows with entries (r=7) and 6 columns (c=6), thus (r-1)(c-1) = 6x5 = 30. For an explanation of this expression, see Hoel, H. P., Introduction to Mathematical Statistics, (3rd edition) John Wiley & Sons, Inc., New York, 1963, p. 253.

RESULTS

The Chi-square statistic is significant at under the .001 level, with degrees of freedom ranging from 24-48, in all but four cases (see Table 6). The exceptions are for growth rate (.044, 30), percentage of families with income greater than $25,000 (.015, 42), percentage of population sewered (.422, 30), and percentage of industrial waste flow (.002, 30). Of this group the only truly insignificant relationship exists between community size and the percentage of population sewered.*

With the highly significant Chi-square statistic in most cases, comparison of actual and expected cell entries suggests the following observations for places of over 25,000 population:

a. growth rate is inversely related to city size (Table 5);

b. the percentage of low income families in larger cities is higher than in smaller cities (Table 30);

c. more small cities than expected have high median family incomes (Table 31);

d. smaller cities demonstrate a greater spread in median family incomes than larger cities (Table 31);

e. smaller cities show a greater range in income than expected and larger cities show a smaller range than expected (Tables 32(a) through 32(c);

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* Population figures in the 1973 Survey of Needs are known to be unreliable. Since it is that set of figures used in the construction of this contingency table, the unreliability of the data may be the cause of this result.

Table 6. CHI-SQUARE STATISTIC

Dependent Variable	Level of Significance	Degree of Freedom
Growth Rate	.044	30
Percent Low Income Families	<.001	24
Median Family Income	<.001	24
Percent With Income 3000	<.001	36
Percent With Income 3-5000	<.001	24
Percent With Income 5-7000	<.001	24
Per Capita Debt	<.001	30
Per Capita Revenue	<.001	36
Percent Sewered	.422	30
Excess Treatment Capacity	<.001	24
Percent Industrial Share	.002	30

f. larger cities have a smaller per capita debt than smaller cities (Table 33);

g. smaller cities have lower per capita revenues than larger cities (Table 34);

h. there appears to be no significant relationship between percent sewered and community size for communities of over 25,000 population (Table 35);

i. smaller cities tend to have more excess capacity than larger communities (Table 36); and

j. more small communities than expected have a high industrial share and fewer moderate size communities than expected have a high industrial share (Table 37).

An examination of the percentage-of-row-total entries shows clearly that all of the characteristics, while depending on population in some fashion, demonstrate rather significant variations within given population groups.

The results of the classification scheme do not suggest relationships which are particularly surprising, but they are important when considering alternative financing schemes, given that communities must build treatment plants and pay a substantial portion of the total cost. The relationships are of three types: (1) those with unfavorable fiscal or equity implications for small cities; (2) those with unfavorable implications for large cities; and (3) those with implications which are independent of city size.

The relationships between city size and growth rate, per capita debt, and per capita revenue fall into the first group. The growth rate tends to be higher in smaller cities and with a more rapid increase in population size comes the need to build a relatively larger treatment plant. This results in higher per capita costs in the early years of operation. From a national perspective this leads to an inequitable distribution of costs. Per capita debt and per capita revenue are not necessarily related to equity, but rather to fiscal issues. Later in this section of the report figures appear which show that the per capita debt is higher for small communities. These figures show that even with a capital grant, a small community with a low per capita debt may face an immediate increase of over 20 percent in this debt figure. Such a sharp rise affects the price a municipality pays to borrow money. Per capita revenue is probably less important than debt, particularly if revenues for the facility are obtained from a user charge. However, as with debt, the percentage change in per capita revenue necessitated by the construction of a plant can be considerable.

For larger cities the factors that have important implications for municipal financing are the relatively high percentage of low income families, the median family income and the excess treatment capacity. A positive relationship exists between the percentage of low income families and city size and, as would be expected from this relationship, the median family income in large cities is lower than the average for all the cities in the sample. Thus, given the portion of the local cost and the manner in which revenues to finance this share are obtained, low income families in large cities bear relatively high costs in relation to their income. Excess capacity tends to be inversely related to community size. Thus, at this point in time, because larger cities do not have as much excess capacity as smaller cities, they will be required to do more in the aggregate and on a per capita basis than smaller ones to increase their treatment capacity to meet the 1977 and 1983 requirements of the 1972 Amendments.

The third set of relationships, those which are independent of city size, illustrates the heterogeneity of cities, even within a given size range. All of the characteristics have a considerable range within any given population class as well as across city size. As obvious as this may be, a grant formula which does not take this diversity into consideration will not account for fiscal impact and equity in the financing of treatment facilities.*

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* One important qualification which must be placed on this discussion concerns the sample of cities used to create the contingency tables. Approximately 56 percent of the population, all those living in cities of less than 25,000, are ignored in the contingency tables constructed from the City and County Data Book. It might be expected that the situation in these communities is considerably different from that which is represented in the sample used but inclusion of these smaller communities can only be expected to further

A full set of contingency tables can be found in Appendix E. In the following paragraphs a municipal model is presented that elaborates for various grant formulas some of the effects on total and per capita costs of such variables as community size, population growth rate, and percentage of industrial flow.

THE MUNICIPAL MODEL AND ANALYSIS

Approach to the Model

One theory* of the municipal expenditure decision process views local budgeting as being driven by internal forces: the resolution of intragovernmental conflicts. This theory suggests that decisions are made through a negotiation process among the parties in the municipal bureaucracy and that this occurs largely independent of local preferences. Proponents of this view focus their analysis on the series of steps that usually constitutes a budgeting process including departmental requests, executive recommendations and legislative appropriations, and see a municipal budget as incrementally changing, driven by the internal bargaining process.[+]

The opposing point of view is based largely on economic and political theories of collective decisionmaking. This theory sees decisions with respect to municipal expenditures as being made by officials attempting to meet the needs and preferences of their constituents -- these preferences being

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(footnote from previous page continued) emphasize the conclusions regarding community heterogeneity and the spread of program impacts. In addition, the units of analysis in the City and County Data Book figures, cities, are not compatible with the units of analysis, treatment facilities, in the 1973 Survey of Needs.

* For review of the literature, see, for example, Appendix A: "Review of Literature on the Budgeting Process" in Scott, Claudia, Forecasting Local Government Spending, The Urban Institute, Washington, D.C., 1972.

[+] An often cited example of this view is Crecine, J. P., Governmental Problem Solving: A Computer Simulation of the Municipal Economy, Rand McNally, Chicago, 1964. But as Scott (ibid.) points out, Crecine also views budgeting as an optimizing process to maximize net social welfare.

a function of social, economic and demographic characteristics of the community.

Both theories have contributed to our modeling of municipal choice of treatment plant, but under the 1972 Amendments most local choice has been removed. Currently, municipalities are being directed to achieve secondary or best-practicable treatment and this requirement is independent of the needs or preferences of the community, and of the public works department's relative negotiating power in capital expenditure budgetary decisionmaking.

CRITERIA, IMPACT MEASURES AND LOCAL CHOICE

The issue of local choice is relevant to this analysis since this choice may be affected by alternative financing programs. These programs may affect what local choice is actually made in contrast to what choice should be made when viewed from the national social perspective. Local decisions may be influenced by criteria and impact measures other than national efficiency. Alternative criteria and impact measures considered in this section reflect a synthesis of the local financing literature and of impressions developed through our professional experience with local and regional institutions. These criteria are present value of local costs, per capita local cost burden, per capita debt burden and administrative feasibility of frequent plant construction.

Under the assumptions of our analysis, local choice excludes options not to build or to delay inordinately. Municipalities may, however, initially build at the secondary treatment level and move up to best-practicable treatment according to a schedule approved before construction by EPA but not later than July 1, 1983.

Municipalities may also select the treatment process with its degree of capital and operating intensities. The analysis was designed to consider biological and physical/chemical processes, but because cost data available to us showed biological treatment to be less costly from both capital and operation and maintenance standpoints, only a few examples are presented using physical/chemical processes. General data on land treatment were not available. Finally, selection of plant scale and mechanisms for financing the local share of costs are local decisions, constrained, of course, by EPA regulations.

WHAT THE MODEL CAN TELL US

The simulation model examines a combination of cases adjudged most relevant based on the classification analysis and those financing alternatives described in Table 7. National efficiency (least resource cost) criterion and the other impact measures discussed above -- present value of local costs, per capita local cost burden, per capita debt burden and administrative feasibility, are evaluated for each case and each financing alternative. The results tell us how financing alternatives affect community and federal financial impact -- whether, for example, some alternatives narrow the variation in costs across communities; the implications of alternative financing programs and local choice criteria for selection of the most efficient treatment option; and the equity of cost burdens for a given financing alternative when examined across communities with different characteristics.

THE CASES

The model was run for representative cities defined by the following parameters: growth rate, percentage of industrial waste flow in total sewage; and the ancillary cost factor.* Eight representative cities are investigated, comprising all combinations of: 1 percent and 5 percent growth rate, zero percent and 50 percent industrial flow and the presence or absence of ancillary requirements. Four city sizes are considered ranging in population from 25,000 to 500,000. The costs of biological treatment are computed and for a population of 75,000, the costs of the physical/chemical treatment alternative are calculated.

The representative cities shown in Table 8 and discussed below cover many of the municipal characteristics that were shown to be significant in the city classification

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* The ancillary cost factor reflects the necessity of constructing interceptors and pumping stations in conjunction with building a treatment plant. In the model the factor is a function of population size and ranges from approximately .5 for small communities to 2.5 for large municipalities. The use of this factor is explained below in the discussion of cost functions.

Table 7.

Alternative	Capital Grant Percent	O&M Grant Percent	Additional Variation
1	0	0	
2	75	0	Capital grant in each decision period for design population
3	75	25	
4	50	0	
5	50	25	
6	50	50	
7	75	0	Grant for capacity for initial population only

Table 8. DEFINITION OF CASES

		Ancillary Works Required				Ancillary Works Not Required				Population (Thousands)
		1	2	3	4	5	6	7	8	
Biological	A	1/0	5/0	1/50	5/50	1/0	5/0	1/50	5/50	25
	B	1/0	5/0	1/50	5/50	1/0	5/0	1/50	5/50	250
	C	1/0	5/0	1/50	5/50	1/0	5/0	1/50	5/50	75
	D	1/0	5/0	1/50	5/50	1/0	5/0	1/50	5/50	500
Physical-Chemical	E	1/0	5/0	1/50	5/50	1/0	5/0	1/50	5/50	75

Each cell is of the form $^{i}/r$, where
i is the yearly population growth rate (percent)
r is the industrial share of flow (percent).

Example: Case 6C is that of a city of 75,000 present population with a 5% growth rate, 0% industrial flow, which selects biological treatment of wastes and needs no building of ancillary works.

analysis. The following discussion does not include cities considered to have highly atypical characteristics.

HOW THE MODEL WORKS

The model examines two sets of decisions: when to build best-practicable treatment and what capacity to build under alternative financing schemes. A planning period of 29 years is assumed with three decision periods as pictured below.*

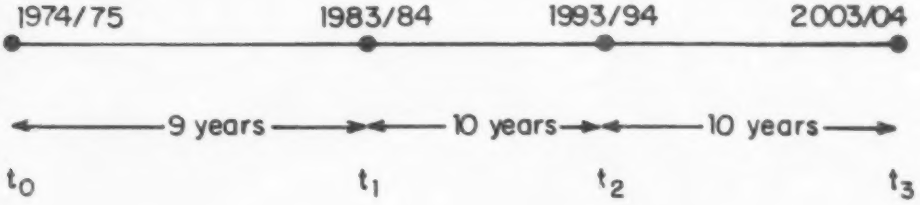

Figure 2 Decision periods within planning period

The possible combinations of decisions (or branches of the decision tree) are defined by the following rules:

1. three decisions are made, one at t_0, one at t_1, one at t_2.

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* The length and number of the decision periods are model parameters that can be varied. However, all results are presented for the three periods shown. The length of the first period results from the difference between present time and the point (1983) after the new standards are operative. The two additional 10-year periods, although arbitrary, reflect the fact that rarely would a treatment plant be built more frequently than every 10 years.

2. at t_0, either secondary or best-practicable treatment may be chosen.

3. at each decision point t_i, capacity sufficient for the population at either t_{i+1}, t_{i+2}, or t_{i+3} may be built.

4. best-practicable treatment must be chosen at or before t_1.

5. if, at t_0, the building of secondary treatment capacity for the population at t_2 or t_3 is chosen, subsequent decisions are limited to upgrading this capacity to best-practicable.

These rules result in twenty possible branches of the decision tree, as shown in Table 9. The decision tree is the same for both biological and physical/chemical treatment.

In Table 9, P_i denotes the population* at time t_i. If r is the yearly population growth rate, then

$$P_i = P_0 \left(1 + r\right)^{t_i - t_0}$$

where t_i and t_0 are in years. ΔP_{mn} denotes the increment of population from time t_n to time t_m:

$$\Delta P_{mn} = P_m - P_n$$

or

$$P_m = P_n + \Delta P_{mn}$$

The symbols S, B, and U denote the decisions made. S denotes building a secondary treatment facility; B denotes building a best-practicable facility; U denotes the upgrading of a secondary facility to a best-practicable facility of the same capacity. These symbols can also be interpreted as the costs of building the facilities, in which case the

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* Population is a surrogate for capacity.

Table 9. TREATMENT DECISION OPTIONS

Option Number	Decision 1 Cost	Decision 2 Cost	Decision 3 Cost
1	$B(P_3)$	---	---
2	$B(P_2)$	---	$B(\Delta P_{32})$
3			$B(\Delta P_{42})$
4			$B(\Delta P_{52})$
5	$B(P_1)$	$B(\Delta P_{21})$	$B(\Delta P_{32})$
6			$B(\Delta P_{42})$
7			$B(\Delta P_{52})$
8		$B(\Delta P_{31})$	---
9		$B(\Delta P_{41})$	---
10	$S(P_3)$	$U(P_2)$	$U(\Delta P_{32})$
11		$U(P_3)$	---
12	$S(P_2)$	$U(P_2)$	$B(\Delta P_{32})$
13			$B(\Delta P_{42})$
14			$B(\Delta P_{52})$
15	$S(P_1)$	$U(P_1)+B(\Delta P_{21})$	$B(\Delta P_{32})$
16			$B(\Delta P_{42})$
17			$B(\Delta P_{52})$
18		$U(P_1)+B(\Delta P_{31})$	---
19		$U(P_1)+B(\Delta P_{41})$	---
20		$U(P_1)+B(\Delta P_{51})$	---

S denotes a secondary facility.
B denotes a best-practicable facility.
U denotes upgrading a secondary facility to best-practicable.

cost associated with any branch of the decision tree is the sum of the costs in that row of the table. For example,

cost of branch 10 = cost of secondary for population at time t_3

+ cost of upgrading part of secondary to best-practicable (upgrade results in best-practicable for population P_2)

+ cost of upgrading remaining secondary (for population $\Delta P_{32} = P_3 - P_2$) to best-practicable.

The model defines B = S + U. Furthermore, all runs assume no existing capacity* (hence there are no ΔP's as arguments in the first column of Table 9) although the model is designed with the capability of analyzing existing capacity. Each cost function used in the model is of the form

$$C_{CAP} = a_1 X_1^{b_1} X_2^{b_2} [1 + f(\Psi)]$$

for capital costs, and

$$C_{O\&M} = a_2 X_3^{b_3}$$

for O&M costs.

The variables and parameters are:

X_1 = design population equivalent (see below), in persons;

X_2 = design flow, mgd;

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* Existing capacity implies another decision tree, which can be derived using the rules above (the decision tree is an input to the program). The cost figures for cases with existing capacity lie in the range of the results for no existing capacity, as one would expect.

X_3 = actual flow, mgd;

Ψ = design population, in persons;

f = ancillary works factor (dimensionless).

Values for the parameters are given in Tables 10 and 11. The population equivalent, X_1, is obtained using the following expression.[*]

$$X_1 = \frac{8.33X_2C}{0.17}$$

where 8.33 = conversion constant, 8.33 lbs/million gallons per mg/ℓ,

0.17 = lbs of 5-day biochemical oxygen demand (BOD) per capita per day,[+]

C = BOD_5 of wastewater in mg/ℓ.

The model calculates flow by assuming an average per capita flow generally 200 gallons per capita per day (gpcd) and multiplying by population. The factor $f(\Psi)$ is used to include the additional costs of constructing interceptors and pumping stations in those cases for which these costs are relevant. This factor is a function of population,[‡] with values as follows:

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[*] Although X_1 is a function of X_2, C is also a variable so that capital cost is really a function of flow and organic load. The expression for capital cost in terms of X_1 and X_2 is used because that is the form most often found in the literature on cost functions. See, for example, Shah, Kanti and George Reid, "Techniques for Estimating Construction Costs of Waste Treatment Plants," J. Water Pollution Control Federation, 42, No. 5, Part 1, May, 1970.

[+] For a discussion of lbs of BOD_5 per capita per day, that might be expected in municipal waste, see Fair and Geyer, op. cit., pp. 262-264.

[‡] Michel, Robert L., "Factors Affecting Construction Costs of Municipal Sewer Projects," draft report, Federal Water Quality Administration, August, 1970.

Table 10. PARAMETERS OF O&M COST FUNCTIONS

	Biological Treatment	
Type	a_2	b_3
Activated Sludge	.042	.876
Filtration	.022	.650
Sludge Handling:		
Sludge Pump	.0021	.452
Sludge Digester	.0095	.712
Sludge Holding Tank	.0015	.530
Vacuum Filtration	.063	.706
Incineration	.0089	.570
	Physical/Chemical Treatment	
Coagulation and Sedimentation	.0147	.986
Filtration	.0136	.638
Carbon Adsorption		
$X_3 \leq 10$ mgd	.1058	.483
$X_3 > 10$ mgd	.0502	.808
Chlorination	.0043	.905
Sludge Handling:		
(as above)		

Note: Secondary biological treatment is defined as activated sludge + sludge handling. Upgrading is defined as the addition of filtration.

Table 11. PARAMETERS OF CAPITAL COST FUNCTIONS

Type	a_1	b_1	b_2
	Biological Treatment		
Activated Sludge	.00812	.461	.262
Filtration	.122	0	.656
Sludge Handling:			
Sludge Pump	.0125	0	.480
Sludge Digester	.0575	0	.650
Sludge Holding Tank	.0224	0	.590
Vacuum Filtration	.326	0	.540
Incineration	.0150	0	.560
	Physical/Chemical Treatment		
Coagulation and Sedimentation	.067	0	.890
Filtration	.122	0	.656
Carbon Adsorption			
$X_2 \leq 10$ mgd	.546	0	.613
$X_2 > 10$ mgd	.293	0	.983
Chlorination	.0202	0	.664
Sludge Handling:			
(as above)			

Note: Secondary biological treatment is defined as activated sludge + sludge handling. Upgrading is defined as the addition of filtration.

$\Psi \leq$	500	but $>$	0	$f = 0.373$
	999		500	0.384
	2,499		999	0.498
	4,999		2,499	0.722
	9,999		4,999	0.790
	24,999		9,999	1.060
	49,999		24,999	1.487
	99,999		49,999	1.533
	249,999		99,999	1.763
$\Psi \geq$	250,000			2.473

The parameters of the cost functions are taken from the literature and are either standard engineering estimates[*] or results of statistical analyses of survey-obtained data.[+] In all cases, the costs given by these parameters and functional forms are not exact, but are mean estimates. For example, cost functions resulting from regression analyses, as in the work of Shah and Reid, have associated with them some standard error of estimate; that is, only part of the variation in costs over the sample analyzed can be explained by the function at hand. The rest of the variation is stochastic in nature. These functions do, however, give reasonably good estimates of cost (i.e., they are not wrong by an order of magnitude) and are adequate when comparing different timestreams of costs, treatment level, and timing.

The computer program for this model runs in interactive mode and accepts as input data the following quantities:

1. per capita flow (gpcd);
2. BOD concentration (mg/ℓ);
3. initial population (1,000's of persons);
4. length of planning periods 1, 2, 3;
5. annual population growth rate (percent);

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[*] Shah and Reid, op. cit.

[+] Black and Veatch, "Estimating Costs and Manpower Requirements for Conventional Wastewater-Treatment Facilities," for Environmental Protection Agency, Project No. 17090 DAN, October, 1971.

6. industrial share (percent);

7. whether biological or physical/chemical treatment and ancillary works required or not;

8. payment period (years);

9. federal capital grant (percent);

10. federal operation and maintenance grant (percent);

11. discount rate (percent);

12. existing capacity (1,000's of persons);

13. different inflation rate (if costs of wastewater treatment facilities are expected to increase at a different rate than the national rate of inflation) (percent);

14. interest rate; and

15. whether grant is given for designs based on existing or projected populations.

Output can be displayed for the following items, for any or all branches of the decision tree, using the local, federal or total share of costs:

1. capital cost;

2. per capita capital cost (three periods);

3. operation and maintenance timestream;

4. per capita operation and maintenance timestream;

5. capital + operation and maintenance timestream;

6. per capita capital + operation and maintenance timestream;

7. per capita capital timestream;

or the present value of any of these items.

A precis of the important steps the program takes is as follows:

1. Populations are calculated, using the initial population and the growth rate.

2. The capital cost is calculated for each branch of the decision tree.

3. An equal-payment timestream of capital costs is calculated using the interest rate.

4. An operation and maintenance timestream is calculated using the population in each year.

5. The user then selects what he wishes displayed. If he wants subsidized costs, the subsidy is calculated and subtracted from the cost. If he wants the present value, the timestream is summed using the discount rate. If he wants municipal or industrial shares, these are broken out. If he wants per capita costs, the costs are divided by the appropriate population figure.

This cycle is repeated each time the user gives a new set of parameters. An example of the calculation the model performs is presented in Appendix F.

Since the model has no explicit normative structure, the user must select a treatment option based on alternative criteria -- minimum total cost, or minimum local cost, for example. The discussion below examines the implications of these alternative criteria for particular representative cities. In most of the examples discussed, comparisons are shown for the selection of the option based on minimum present value of total resource costs (the socially least-costly option to meet the mandated control level).

Unless otherwise noted, it is assumed in each of the cases discussed that each community finances its capital expenditure with a 30 year equal payment scheme based on capital borrowing at 6 percent interest and that the present values of resource costs are calculated on a discount rate of 7 percent reflecting the Water Resources Council guidelines as adopted by EPA regulations.*

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* Federal Register, Vol. 38, No. 174, Monday, September 10, 1973, "Title 40--Protection of the Environment, Chapter 1--Environmental Protection Agency, Subchapter D--Grants, Part 35--State and Local Assistance, Appendix A--Cost Effectiveness Analysis," pp. 24639-24640, Section (f)(5).

REVIEW OF ASSUMPTIONS

It is useful at this point, prior to discussing results of the simulation model analysis, to review the important assumptions in the model and its analytical framework.

Some of these assumptions have been explicitly stated earlier in this report, others are implicit in the model structure and cost of treatment functions utilized.

The most important assumption stated a number of times in this report is that the municipality must select a particular treatment option. A no-treatment or significant-delay option is not included. Another assumption is the limitation of treatment options to the discrete number considered rather than a series of options. However, the option with capacity based on 10 year increments and a range of treatment levels does bound the range of options.

There are a number of assumptions implicit in the model structure and the cost functions employed. First, it is assumed that selection is primarily between mode and degree of treatment, i.e., physical/chemical vs. biological, secondary vs. best-practicable. For a given mode and treatment level, there is a single point production function and cost functions are dependent on scale. Thus, the relative ratio of capital to O&M costs to achieve a given treatment level cannot really be varied except by changing treatment modes, i.e., using physical/chemical rather than biological. The only qualifier results from the fact that unit operating costs are a function of treatment plant size, hence the operating costs of a plant with excess capacity has slightly different operating expenses than one operating at capacity.

Although it is known that tradeoff between capital and O&M is possible, there is no basis in the professional literature for estimating such production functions that could have been utilized in this analysis.

The limitation of then comparing only between treatment needs to examine relative capital vs. O&M resources used is further constrained by the paucity of generalized developed cost literature on physical/chemical and land treatment options. The limited generalized cost literature on physical/chemical indicates that it is universally dominated by biological and there is no generalized cost literature on land treatment.

There are unquestionably specific cases in which physical/chemical or land treatment would dominate biological options, but at this writing the technological relationships and cost functions are not available to provide the type of comparison that would be useful.

RESULTS

Table 12 shows the present value (PV) of local costs of the four least costly treatment options for case 1A (see Table 8). In this case the small federal share of total present value of treatment costs is noteworthy. For a city of 25,000 and a 1 percent growth rate, no ancillary costs and no industrial load, the PV at 7 percent discount rate of total costs is given in Table 13 to be $6.617 million. This is the minimum total cost represented by option 12. In this case the model calculations show that the PV of capital costs is 37 percent of this $6.617 million. Local costs with a 75 percent construction grant are $4.772 million (see Table 12). Thus, federal aid is only 28 percent of total costs.*

It is interesting to consider the implications of choosing one of the other options. Option 11, building 30 years of secondary capacity initially, would be more attractive from a local point of view under a choice criteria of minimizing administrative burden since it provides more initial capacity and necessitates only one upgrading. The local administrative burden, in terms of the frequency of undertaking the planning grant application, construction and bond issuance, is less than that of option 12. At the 7 percent discount rate the PV of local costs for these options is the same. At the higher (10 percent) discount rate the PV local cost for a lesser administrative cost is an extra $0.15 million ($3.688 - $3.673). The national efficiency losses associated with such a difference are small ($.002 million at 7 percent, $.07 million at 10 percent) the capital requirements of an extra 10 years of initial capacity are significant. Consequently, if federal budget limitations constrain the rate of facility construction, such an additional requirement for grant monies can

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* $\frac{6.617 - 4.772}{6.617} = 100 = 28$.

Table 12. PRESENT VALUE OF LOCAL COSTS FOR CITY OF 25,000 WITH 1% GROWTH RATE, NO ANCILLARY COSTS, NO INDUSTRY AND NO EXISTING UPGRADABLE TREATMENT CAPACITY (DISCOUNT RATES OF 7% AND 10%)

The Four Least Costly Options $\$X10^6$

	7% Discount Rate Option				10% Discount Rate Option			
Grant	12	11	10	15	12	11	10	15
50% Capital	5.387	5.388	5.391	5.456	4.248	4.279	4.280	4.286
75% Capital (present program)	4.772	4.772	4.774	4.806	3.673	3.688	3.689	3.692
50% Capital; 25% O&M	4.347	4.349	4.352	4.416	3.474	3.504	3.506	3.511
50% Capital; 50% O&M	3.308	3.310	3.313	3.377	2.699	2.730	2.731	2.737

Options:

	Decision 1	Decision 2	Decision 3
12	Build secondary for P_2	Upgrade to best-practicable for P_2	Build best-practicable for ΔP_{32}
11	Build secondary for P_3	Upgrade to best-practicable for P_3	---
10	Build secondary for P_3	Upgrade to best-practicable for P_2	Upgrade to best-practicable for ΔP_{32}
15	Build secondary for P_1	Upgrade to best-practicable for P_1 and build best-practicable for ΔP_{32}	Build best-practicable for ΔP_{32}

Table 13. PRESENT VALUE OF TOTAL COSTS, CITIES WITH 1% GROWTH RATE, NO INDUSTRY

	7% Discount Rate				10% Discount Rate			
Population/Option	12	11	10	15	12	11	10	15
25 Thousand	6.617* 10.275**	6.619 10.281	6.626 10.299	6.755 10.618	5.399 8.820	5.460 8.973	5.462 8.979	5.474 9.007
75 Thousand	14.645 22.452	14.659 27.487	14.674 22.523	14.918 23.142	11.893 19.198	12.027 19.537	12.032 19.549	12.038 19.565
250 Thousand	35.517 63.708	35.569 63.886	35.600 63.995	36.097 65.721	28.692 55.087	29.007 56.182	29.017 56.217	28.992 56.129
500 Thousand	59.571 104.572	59.670 104.917	59.719 105.090	60.470 107.697	47.977 90.130	48.509 91.924	48.494 91.979	48.435 91.719

* Without ancillary costs

** With ancillary costs

Note: The relative ranking of options remains the same for each of these populations for local PV based on the grants shown in Table 12.

have important national implications for the rate of water pollution control. The primary implication is for much larger initial costs and higher budget requirements in the early years of the program or, alternatively, greater delays in the early program years if a limited budget covers fewer municipal requirements.

Table 12 presents the present value of local costs for the four least-cost (PV) decision options. The costs are for a small city with low growth rate, no ancillary costs and no industry. The PV ranking, based on local costs, is the same ranking as that based on total costs as shown in Table 13. Table 13 indicates that this relative ranking of treatment options by PV of total costs is maintained for other city sizes whether or not there are ancillary costs, or a low growth rate and no significant industrial load. The ranking in Table 13 is preserved for PV of local costs under the financing options shown in Table 12. For a given financing program, the difference in PV, either local or national, between the more attractive options is small. Thus, the PV associated with the selection of the more costly option is itself hardly significant, but again the implications for the short-term federal budget can be significant.

Continuing the earlier discussion, it is useful to consider some implications of municipal selection of option 11 based on local administrative criteria. For the cases presented in Table 13 without ancillary requirements, the efficiency losses as measured in the PV of total costs at 7 percent range from $.002 million for the 25,000 population case discussed above to $.099 million for the city of 500,000 population. The efficiency losses may be considered insignificant. The difference in initial capital requirement, however, ranges from $.15 to $1.1 million and 75 percent of this would represent additional federal budgetary requirements being incurred earlier in the program rather than later.

Table 14 shows that for populations from 25,000 to 500,000 having high growth rates, option 12 has the least PV of total and local costs at the lower discount rate, while option 15 has the least PV at the higher discount rate.

At the lower discount rate the ranking after option 12 changes for cities with high growth rates (Table 14) relative to those with lower growth rates (Tables 12 and 13). The rankings in Table 14 are maintained when based on

Table 14. PRESENT VALUE OF TOTAL COSTS CITIES WITH 5% GROWTH RATE AND NO INDUSTRY

	7% Discount Rate				10% Discount Rate			
Population/Option	12	15	18	2(1)	15	12	18	5
25 Thousand	10.527* 17.349**	10.635 17.619	10.857 18.132	11.062 18.177	8.173 14.056	8.300 14.371	8.488 14.819	8.646 14.790
75 Thousand	23.265 38.318	23.456 39.315	23.937 40.645	24.362 39.923	17.949 31.178	18.243 31.534	18.619 33.031	18.918 32.638
250 Thousand	56.305 109.163	56.652 110.369	57.781 114.29	58.710 113.768	43.143 88.495	43.879 91.054	44.685 93.851	45.268 92.582
500 Thousand	94.305 178.929	94.789 180.612	96.635 (2)	98.084 186.174	71.982 144.458	73.225 148.775	74.478 153.126	75.322 150.889

* Without ancillary costs

** With ancillary costs

Note: The relative ranking of options remains the same for each of these populations for local PV based on the grants shown in Table 12.

(1) Notice the reversal of 18 and 2 at 75,000, 250,000 population with ancillary costs.

(2) For 500,000 population with ancillary costs, branch 2 is ranked 3 and branch 5 is ranked 4.

local cost present values for any of the grant programs presented in Table 12.

Tables 12 through 14 indicate the ranking of options based on PV of either local or total costs is quite stable for the four financing alternatives and two discount rates presented. This stability of ranking breaks down at higher discount rates. Under the present value criterion, this would suggest building less capacity initially. These tables also indicate that for particular municipal cases, the PV difference between options is usually quite small.

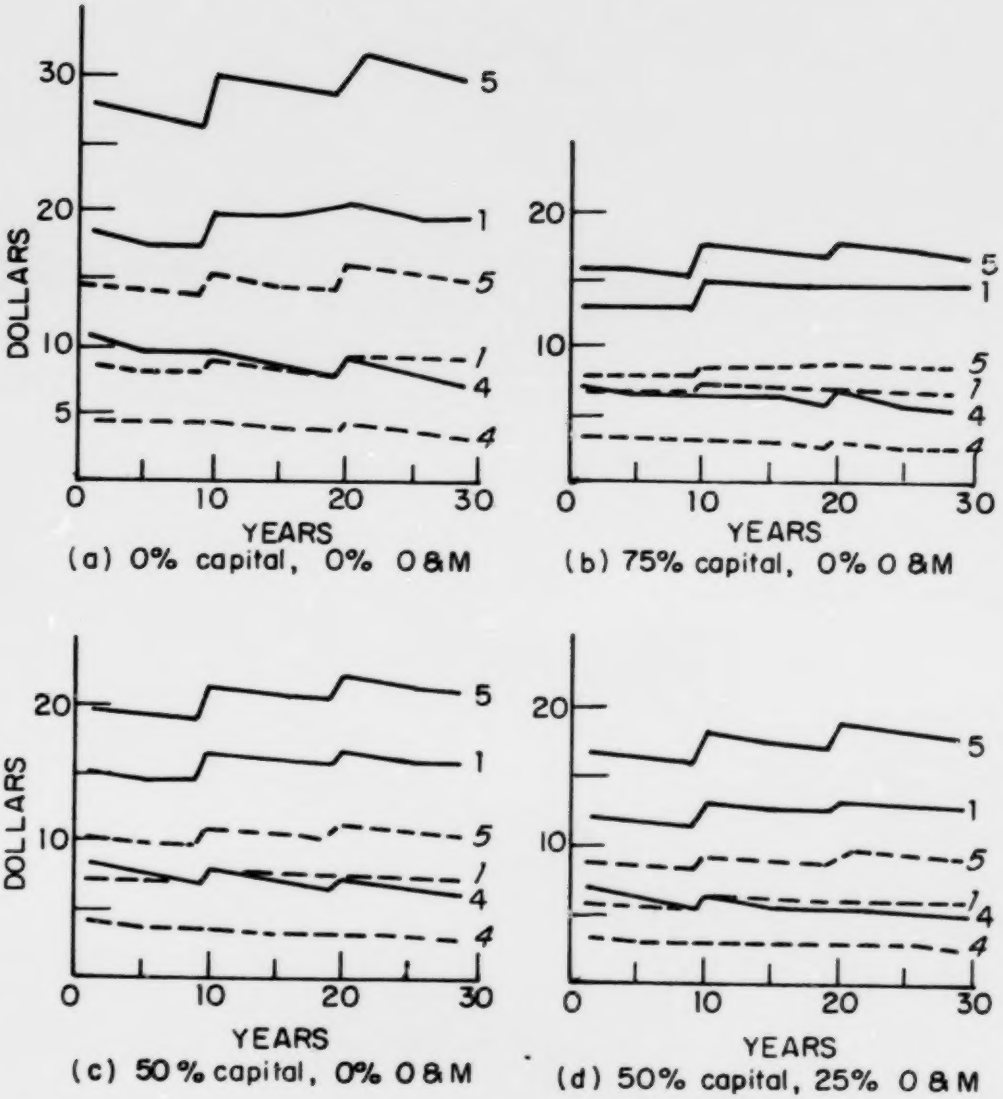
These overall results are not terribly startling. The options are from the same treatment mode -- biological -- the options differ primarily in capacity and treatment level timing selection. The relative percentages of the capital and O&M cost stream of the different options are quite close; hence, under the present value criteria these financing alternatives impact the cost stream to nearly the same degree.

Figures 3(a) through 3(f) present the local per capita cost streams for a number of cases defined in Table 8 under the alternative levels of federal financing. These cost streams are based on the assumption that municipalities select the treatment option that minimizes the present value of local costs. For the options considered and the discount rate used (7 percent), this option (option 12) is also the option with the minimum present value of total cost.

The per capita costs vary considerably under any of the financing programs discussed thus far in this section. Similar variation in per capita costs can be observed under different assumptions of local selection criteria. If, for example, the cities select option 11, which implies a lower administrative burden, then the per capita timestream of costs demonstrates the same relative variation.

The cases presented in these figures are representative of the range of results of the analysis. Other cases from Table 8 would generally lie within the band represented by the cases in these figures.

Figure 3(a) shows that, with no grant, per capita costs can easily differ by as much as a factor of four between communities representative of large numbers of real communities.



(a) 0% capital, 0% O&M
(b) 75% capital, 0% O&M
(c) 50% capital, 0% O&M
(d) 50% capital, 25% O&M

Figure 3 Per capita municipal cost for biological treatment branch 12, with various grant levels
(—— 25,000; - - - 500,000)

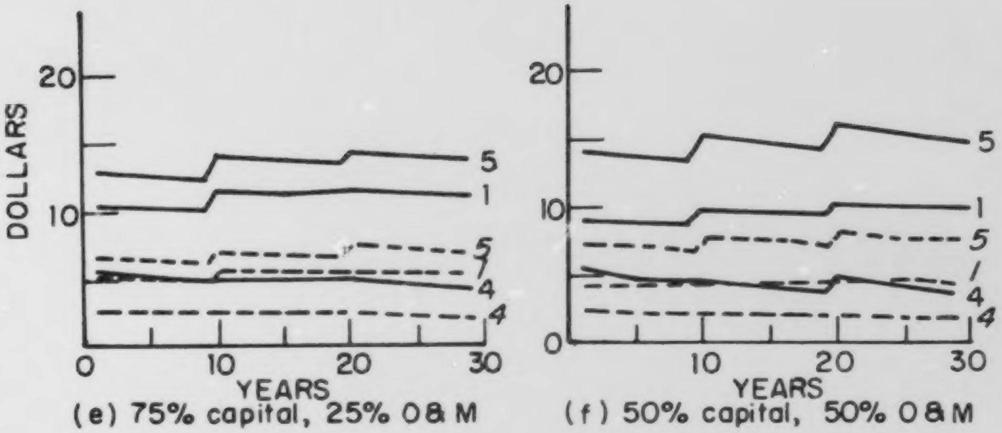


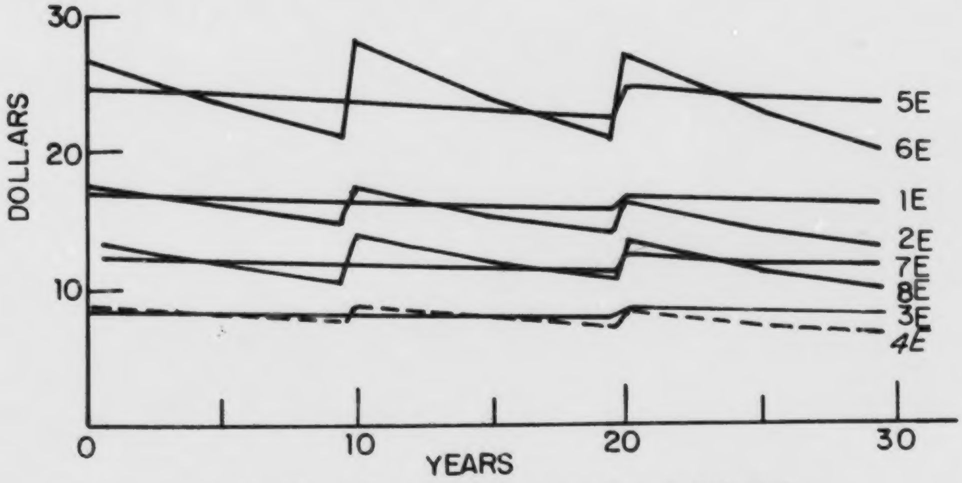
Figure 3 (cont.)

The existing program [Figure 3(b)], although decreasing the absolute per capita costs, does not markedly change the variation in costs among communities and thus does little to diminish this inequity. A 75 percent capital, 25 percent operation and maintenance grant program [Figure 3(e)] narrows the spread in per capita costs, but there can still be a factor in excess of two between per capita costs borne by different cities.

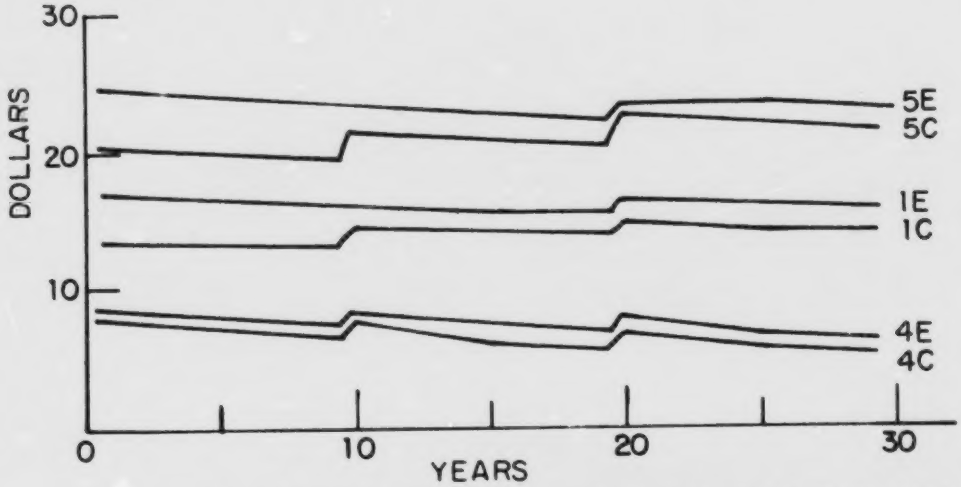
The growth rates and population/industrial share depicted in Figure 3 represent the majority of the population/growth rate classes and population/industrial share classes identified in the classification analysis (see Tables 5 and 37). Figure 4 emphasizes the variation in per capita costs for cities of 75,000 with different growth rates and industrial loads. As in Figure 3 the cost streams presented are for the least present value options only; examples for both biological (cases C) and physical/chemical (cases E) are presented. In the biological cases option 12 is the least cost while in the physical/chemical cases option 2 or 5 is the least cost option.

Figures 5 and 6 provide further emphasis of these points. In both figures the first year per capita costs (for option 12) are shown for a range of capital and operating cost grant levels. Figure 5 considers a city of 75,000 population and shows the impact of growth rate, industrial load and ancillary costs on per capita costs. The presence of significant industrial load decreases per capita costs. The decrease results from the lower marginal costs associated with a larger treatment plant (economies of scale) which treats both domestic and industrial waste load. Since it is assumed that industry shares cost in proportion to its share of the flow, the municipal costs share is lower than the total costs without industry. Hence, costs per capita are also lower. In other case comparisons the presence of ancillary needs -- interceptor and pumping stations in addition to treatment works -- increase total costs and hence per capita costs.

Figure 6 presents first year per capita costs for small (25,000 population) and large (500,000 population) communities with a variety of characteristics. The variation in per capita costs is even more dramatic than in Figure 5.

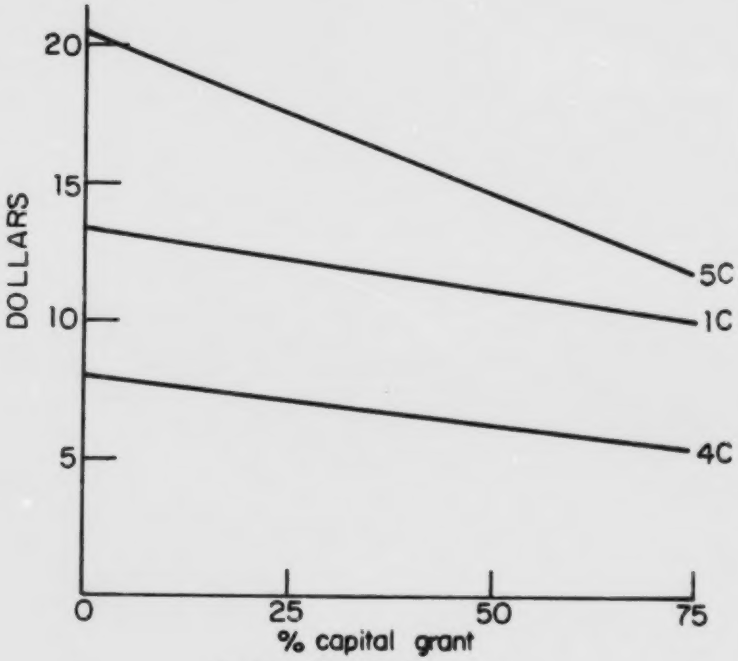


(a) Case E: physical chemical treatment

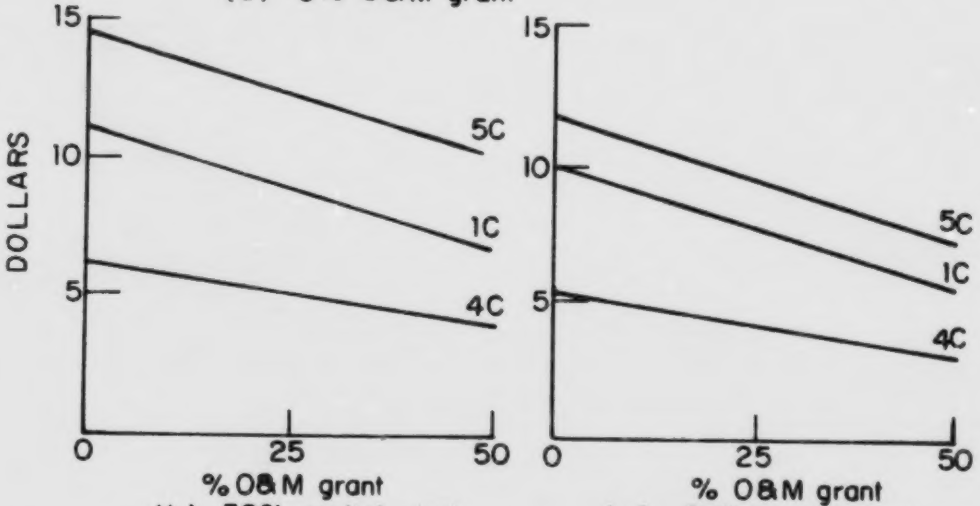


(b) Cases C and E: biological and physical/chemical treatment

Figure 4 Per capita municipal cost with no grants and 75,000 initial population



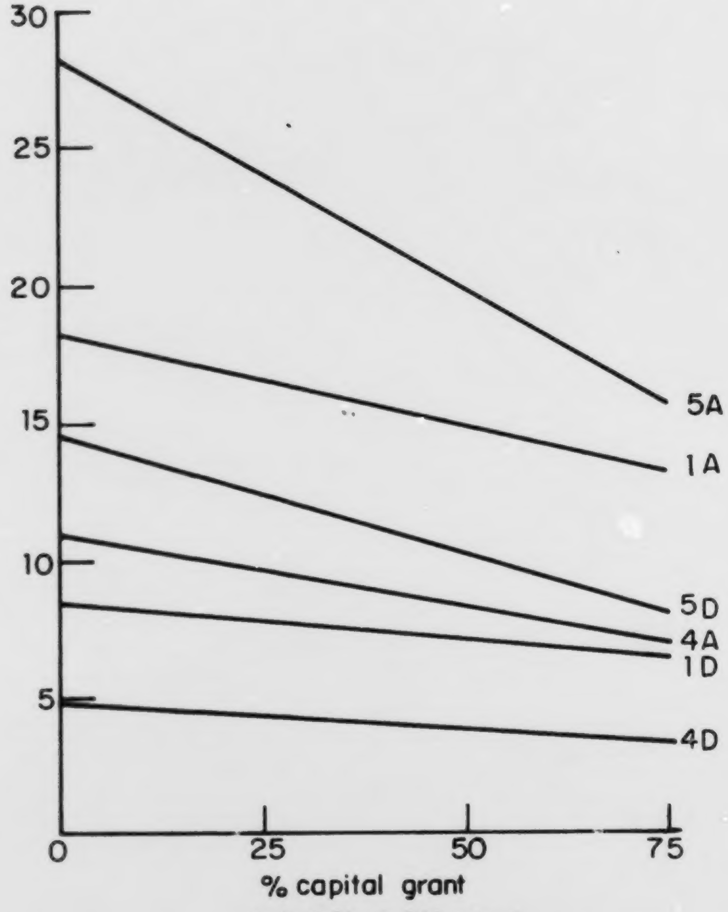
(a) 0% O&M grant



(b) 50% capital grant

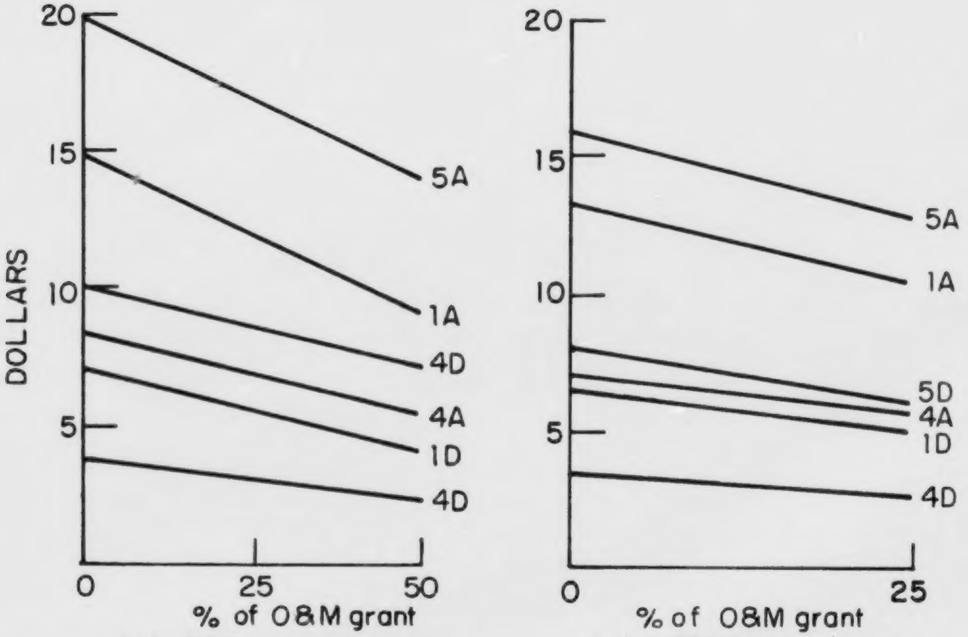
(c) 75% capital grant

Figure 5 First year per capita municipal cost as a function of grant levels (Case C: city of 75,000 with biological treatment)



(a) 0% O&M grant

Fig 6 First year per capita municipal cost as a function of grant levels (Cases A & D: cities of 25,000 and 500,000 with biological treatment)



(b) 50% capital grant

(c) 75% capital grant

Figure 6 (cont.)

The locally-borne per capita costs range -- for the cases shown, and for the present grant program -- from less than $5 per capita/year to over $25. The addition of an operation and maintenance grant reduces the variation in per capita costs, but significant variation still exists.

Financing programs which only subsidize the requirements of existing populations further exacerbate variations in per capita costs. In general, cities with higher growth rates are more seriously affected. Figure 7 presents the difference in per capita costs for a few cases in which the present 75 percent capital grant is compared with a grant program that funds only that capacity needed by the existing population. The cases selected do not represent extreme situations, but nonetheless the impacts are significant. Such a grant limitation increases already high per capita costs for case 1A, a city of 25,000 population, with no ancillary costs, a 1 percent growth rate, and no industry. Case 4D, a large city of 500,000 population, again with no ancillary costs, but this time with a high growth rate, has per capita costs that almost double under this financial program. The impact of this curtailed grant program on a small city (25,000 population) with no industry and a high growth rate (5 percent) but no ancillary costs, is to increase annual per capita costs by over 20 percent -- as presented in Figure 7.

Figure 8 presents the first year per capita debt for some of the cases examined above. As expected, as the capital grant increases, the per capita debt decreases. In the range of 50-75 percent there is still, however, a large spread in the implicit per capita debt ranging from less than $20 per capita to over $100. The impact for some communities can be significant.

A NATIONAL OPERATION AND MAINTENANCE GRANT ANALYSIS

In this section the federal cost of an operation and maintenance grant program is discussed. The 1973 Survey of Needs data base is used in this analysis. The computation of the cost of an O&M program is straightforward. However, there are some problems due to the fact that not all the records are complete.

To compute the costs of an O&M program, functions are developed which relate the O&M costs for a facility to the

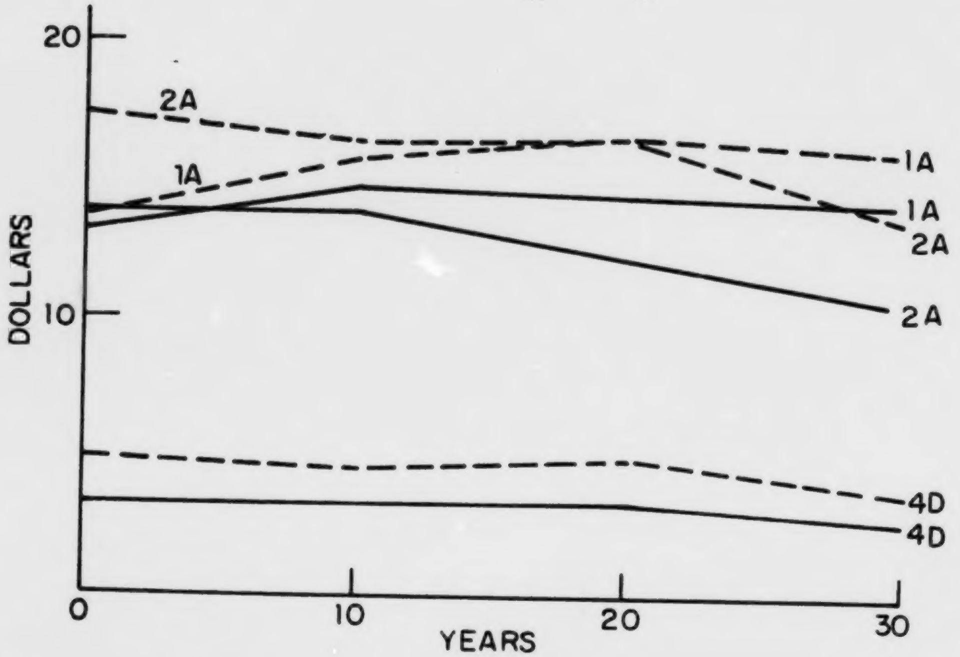


Figure 7 Per capita municipal cost for grant based on existing population (---) and grant based on projected population (——) (75% capital and 0% O&M)

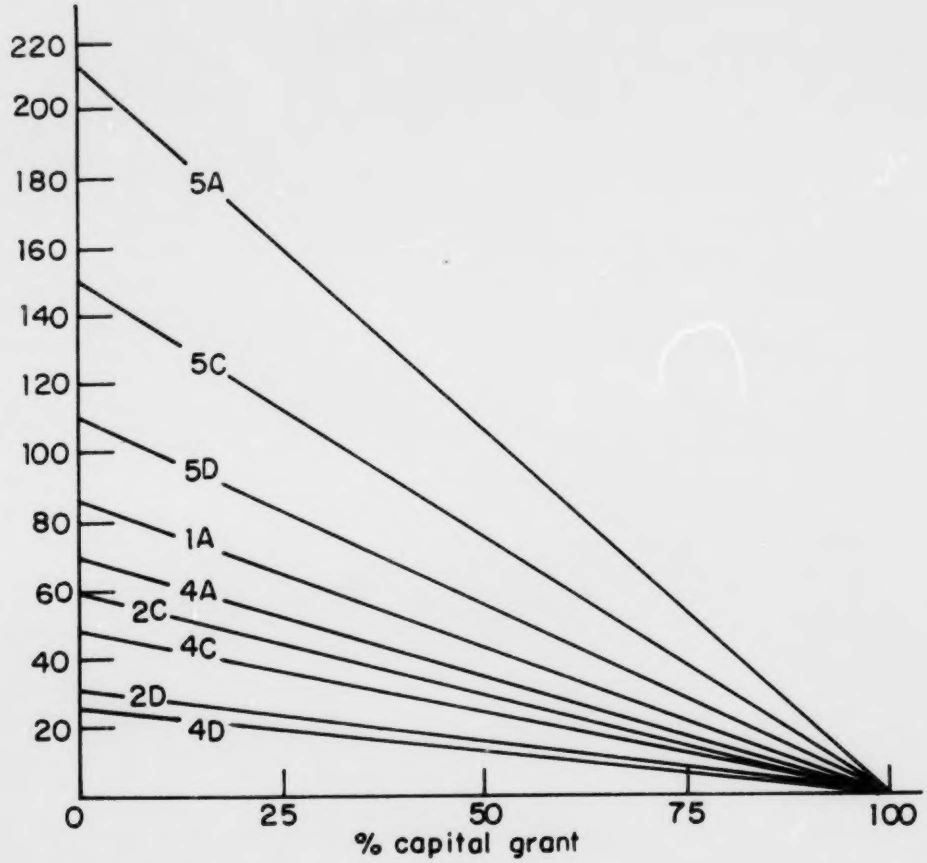


Figure 8 First year per capita municipal debt as a function of capital grant (0% O & M grant)

state's capital cost estimates for that facility. Expressions that define annual operation and maintenance costs for various types of treatment plants or unit processes as functions of estimated capital costs are obtained by assuming that, for a given process, the capital and operation and maintenance cost functions are of forms similar to those in the previous section:

$$C_{1j} = \alpha_{1j} X^{\beta_{1j}}$$

$$C_{2j} \quad \alpha_{2j} X^{\beta_{2j}}$$

where

C_{1j} = capital cost in $\$ \times 10^6$ for a treatment plant or unit process type j;

C_{2j} = annual operation and maintenance costs in $\$ \times 10^6$;

X = flow in mgd;

and the α's and β's are parameters. The parameters are obtained as explained before. From these one obtains the function relating O&M cost to capital cost the expression:

$$C_{2j} = \alpha_{2j} \left(\frac{C_{1j}}{\alpha_{1j}} \right)^{\beta_{2j}/\beta_{1j}}$$

An operation and maintenance cost estimate, $\hat{C}_{2j}$ for each treatment facility can then be obtained by using the capital cost estimate, $\hat{C}_{1j}$ as the argument in this equation. The individual facility costs can then be summed on a state, regional or national basis.

To compensate for incomplete data, a chain of default data is used which enables us to utilize the available data to the greatest possible extent. As the items crucial to the analysis were the capital cost of the facility and its BOD removal level, each facility record was subjected to the following processing:

a. If no capital cost was given, the record was not used.

b. If capital cost was given, but no BOD removal level was given (i.e., one or both of the figures for influent and effluent BOD levels was absent), a figure of 170 mg/ℓ (85 percent removal of 200 mg/ℓ influent) was assumed for the BOD removal level.

c. If a flow figure was given, it was then used to calculate the total BOD removal.

d. If no flow figure was given, an attempt was made to calculate one from the 1970 population.

    i. If no 1970 population was given, the record was not used.

    ii. If a 1970 population was given, a 1990 design population was calculated from it using a 2 percent growth rate.

    iii. The flow was then calculated from the 1990 population assuming a per capita flow of 120 gpcd.

Table 15 presents estimates for each state for annual operation and maintenance costs. For the records used the total of the states' estimates is \$3.02 billion. These results show that a 25 percent operation and maintenance grant would cost approximately \$.75 billion per year for the proposed new plants and additions to existing plants required to meet the legislative mandate. This estimate is probably somewhat low since all of the records for each state's new facilities were not usable in computing the \$3.02 billion estimate.*

Estimates of the cost of providing operation and maintenance grants to existing facilities were made by first determining the replacement value of existing facilities.

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* In Table 15, the column labeled "Percent Used" shows that 57.3 percent of all the treatment facilities records were used. The figure is based upon a ratio of new facilities records which were usable to all of the treatment facilities records contained in the needs survey.

Table 15. COSTS OF OPERATION AND MAINTENANCE GRANT PROGRAM

State	Region No.	O&M Cost ($X10^6)	Treatment Facility Records	Records Used	Percent Used
Alabama	4	12.34	202	135	66.8
Alaska	10	18.58	71	60	84.5
Arizona	9	15.81	140	71	50.7
Arkansas	6	6.71	119	115	96.6
California	9	385.56	654	353	54.0
Colorado	8	29.07	173	117	67.6
Connecticut	1	52.89	123	33	26.8
Delaware	3	16.48	25	16	64.0
District of Columbia	3	6.27	2	1	50.0
Florida	4	141.87	229	110	48.0
Georgia	4	30.47	349	210	60.2
Hawaii	9	40.76	49	30	61.2
Idaho	10	4.26	59	34	57.6
Illinois	5	150.97	596	359	60.2
Indiana	5	39.84	236	148	62.7
Iowa	7	34.54	314	261	83.1
Kansas	7	15.32	162	126	77.8
Kentucky	4	35.30	124	76	61.3
Louisiana	6	6.95	214	130	60.7
Maine	1	16.72	142	88	62.0
Maryland	3	78.08	80	40	50.0
Massachusetts	1	74.02	85	38	44.7
Michigan	5	103.39	223	109	48.9
Minnesota	5	69.94	234	115	49.1
Mississippi	4	8.09	93	73	78.5
Missouri	7	75.49	263	151	57.4
Montana	8	6.39	63	30	47.6

Table 15. (continued)

State	Region No.	O&M Cost ($\$X10^6$)	Treatment Facility Records	Records Used	Percent Used
Nebraska	7	22.38	148	115	77.7
Nevada	9	24.28	44	20	45.5
New Hampshire	1	45.78	91	79	86.8
New Jersey	2	335.48	248	123	49.6
New Mexico	6	5.68	40	23	57.5
New York	2	300.23	647	273	42.2
North Carolina	4	35.89	182	122	67.0
North Dakota	8	0.42	95	54	56.8
Ohio	5	197.09	502	295	58.8
Oklahoma	6	14.98	202	181	89.6
Oregon	10	19.87	87	6	6.9
Pennsylvania	3	150.83	726	430	59.2
Rhode Island	1	13.57	25	17	68.0
South Carolina	4	29.27	382	249	65.2
South Dakota	8	3.19	113	53	46.9
Tennessee	4	41.97	140	70	50.0
Texas	6	40.60	683	294	43.0
Utah	8	18.76	107	72	67.3
Vermont	1	6.86	105	71	67.6
Virginia	3	98.14	638	200	31.3
Washington	10	56.98	105	68	64.8
West Virginia	3	11.61	401	310	77.3
Wisconsin	5	42.27	186	79	42.5
Wyoming	8	0.83	36	34	94.4
Wake Island	9	---	0	0	0.0
American Samoa	9	0.35	3	3	100.0
Guam	9	1.85	7	6	85.7
Puerto Rico	2	22.88	45	36	80.0
Trust Terr.	9	0.21	8	0	0.0
Virgin Islands	2	1.29	4	4	100.0
		3,019.65	11,024	6,316	57.3

In the 1972 Economics of Clean Water a replacement value of $18.87 billion (1971 dollars) is reported based upon records for 12,380 facilities.* To be comparable with the 1973 dollars used in this report, the figure is approximately $21.42 billion. In an analysis of the usable records on existing facilities (7,498) in the 1973 Survey of Needs an estimate of $11.69 billion (1973 dollars) was obtained.+ Multiplying $11.69 by the ratio of the number of records used in the 1971 estimate (12,320) to the number of records used in 1973 (7,498) this figure becomes $19.7 billion. It is reasonable to assume then that those existing facilities in the country for which information is available have a replacement value of approximately $20 billion.

Next the works of Smith and of Black and Veatch were reviewed.‡ Estimates of the ratio of annual operating and maintenance costs to capital costs were found to vary from 0.06 to over 0.15, depending on treatment process and scale. Reasoning that current operation and maintenance costs are rising more rapidly than capital costs, it has been assumed that the appropriate ratio to use is 0.12.

Thus, using a replacement value of $20 billion and annual O&M to capital cost ratio of 0.12, we find that a grant program providing funds for 25 percent of the annual costs would require $0.6 billion. The total cost of a 25 percent O&M grant program, for new and existing facilities, is therefore estimated to be $1.35 billion.

There are several qualifications which must be placed on this estimate:

a. there may be double counting in that some of the new facilities will be replacing existing facilities;

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* Economics of Clean Water, Vol. I, 1972, p. 120

+ Municipal Waste Treatment Facilities Evaluation Model, Meta Systems Inc., 1974, p. 8.

‡ Smith, R., "Cost of Conventional and Advanced Treatment of Wastewater," J. Water Pollution Control Federation, September, 1968, pp. 1546-1574; and Black and Veatch, op. cit.

b. the replacement value underestimates the total replacement value of facilities since records on all facilities are not available; and

c. there is reason to believe that the figures on the 1973 Survey of Needs (capital cost figures) and used herein to estimate O&M costs, are substantially overstated.

Finally, it should be pointed out that the cost estimates are for treatment only and not for the maintenance of collection systems.

CONCLUSIONS

The current federal program of 75 percent construction grants results in only a modest federal contribution to the total municipal water pollution control costs mandated by the 1972 Amendments: less than 25 percent of total costs for large numbers of communities.

The community characteristics of population, growth rate, fiscal situation, wastewater system characteristics, industrial share of wastewater load and family income structure exhibit wide variations across the nation and along with varying ancillary needs imply large differences in per capita costs borne by communities under the existing federal construction grants program. For example, the results of contingency table analysis of population and industrial flow data taken from the 1973 Survey of Needs demonstrate a clear relationship between community size and percentage of industrial flow. More importantly, the analysis shows that the percentage of industrial flow is distributed bimodally with community size. What that means is that many communities of a given size have very low industrial flows and many have high industrial flows. We can expect, then, that a large number of municipalities with rather similar characteristics (except for the presence of industrial flow) will have rather different per capita costs. Therefore in order to alleviate inequitable per capita costs burdens, industrial flow and other community characteristics should be included in the grant formula.

The alternative of a construction grant program that restricts the size of treatment facilities to meet only existing population makes more severe the variation in per capita costs across communities and results in a less efficient utilization of resources.

The equity arguments in favor of a 75 percent construction grant mitigate against any reduction in the grant percent, especially considering the modest federal contribution to the total cost to municipalities of nationally-mandated water pollution control unless such a reduction is coupled with an operation and maintenance grant. But even the inclusion of a significant operation and maintenance grant percentage does not eliminate the extreme variation of cost burden.

This situation of serious differences in per capita costs may be aggravated by the distribution of family income and the serious differences in communities' ability to finance these costs. (See tables in Appendix E.) Focusing on the family income question, we have seen that the range of median family income is not insignificant across municipalities of a given size. If it can be assumed that family income and the presence of industry are independent, then there will be a fair number of poorer communities with higher per capita costs being paid by a population that contains a large number of poor families. If the presence of industry and family income are correlated positively, then the situation is worse; while if they are correlated negatively, this effect is reduced somewhat.

The potential implications for some income classes also can be quite significant, again for those cases that under the financing programs presented in Figures 4 to 5 result in first year per capita costs of $10-20. If these costs were paid through user charges, there could be extreme group distribution impacts. A $10-20/year per capita user charge (nearly equivalent to a head tax non-deductible from federal income taxes) is a strongly regressive mechanism. Property taxes to finance this $10-20 may be less regressive in impact, but are beyond analysis of this study. Mechanisms are necessary to eliminate such potential regressive impacts. But more analysis is needed.

The analysis furthermore indicates that there are substantial differences in communities' abilities to finance these costs, i.e., revenue capacities of communities are drastically different as shown in Table 34.

The implication is that the local burden of federal requirements for waste treatment (the local cost per dollar of revenue capacity) varies significantly. As a consequence, we think the highest priority should be given to the development of new policy tools that permit restructuring of the grant program such that the burden on communities becomes less inequitable. This may be accomplished through a grant formula that reflects both differences in costs to communities and differences in communities' abilities to finance those costs, i.e., differences in communities' revenue capacity.

Current practice for federal programs that attempt to reflect differences in community revenue capacity is to use personal income as a measure of revenue capacity. Although we are familiar with the theoretical and practical difficulties of use of income as a measure of revenue capacity,* we believe that it should be possible to derive a meaningful and useful grant formula based upon income as a measure of community revenue capacity with the possibility of modification depending on large differences in local wealth (assessed valuation of property), tourism, and revenues derived from exploitation of mineral resources.

Hence, there is a need on equity grounds for a new complex grant formula. The grant formula design might include several components. Per capita financial burdens across municipalities should be made more nearly equal with provisions in the formula to account for the cost effects of a municipality's population size, growth rate, income structure, percentage of industrial flow and the need to build ancillary facilities. Special compensating provisions should be made to municipalities to reflect the cost impact on low income groups.

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* Advisory Commission on Intergovernmental Relations, "Measuring the Fiscal Capacity and Effort of State and Local Areas," Washington, D.C., Government Printing Office, March, 1971.

SECTION 5

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APPENDIX A

LEGISLATIVE HISTORY OF FEDERAL WASTEWATER FINANCING PROGRAMS

The current version of the Federal Water Pollution Control Act has its roots in Public Law 80-845, passed in 1948, which authorized loans and other assistance to states and municipalities trying to deal with water pollution. Public Law 80-845 declared it to be the policy of Congress

> to recognize, preserve, and protect the primary responsibilities and rights of the States in controlling water pollution, to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment, and to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs. [Section 1]

The Surgeon General under the Public Health Service, the Federal Works Administrator, and the Federal Security Administrator were to administer the program. Under Section 5 the Federal Works Administrator was authorized to make loans to states, municipalities, or interstate agencies to construct treatment works preventing the discharge of untreated or inadequately treated wastes. Loans could also cover the preparation of engineering reports, plans, and specifications. Loans were to be made only if a project was approved by the Surgeon General and appropriate state agency and was part of a "comprehensive" plan. Loans were limited to a federal share of 33.3 percent of the "estimated reasonable cost" or $250,000, whichever was smaller, and carried an interest rate of 2 percent. Section 5 also provided that:

> bonds or other obligations evidencing any such loan (1) must be duly authorized and issued pursuant to State and local law, and (2) may, as to the security thereof and the payment of principal thereof and interest thereon, be subordinated [with agreement of Federal Works

> Administrator] to other bonds or obligations of the obligor issued to finance such project or that may then be outstanding.

Projects were to be ranked by considering the "public benefit to be derived," the "propriety of Federal aid in such construction," the relation of the full costs of construction and maintaining works to public interest and necessity, and the "adequacy of provisions ... for assuring proper and efficient operation and maintenance of the works" after construction.

Public Law 80-845 authorized $22.5 million for loans under Section 5 for each fiscal year from 1948 to 1953 [Section 7] and $1 million for those years for grants for the preliminary planning and engineering work on approved projects. Public 82-579 extended the life of 80-845 until June, 1956. The funds, however, were never actually appropriated.*

Public Law 80-845 was substantially amended in 1955-56, 1961, 1965-66, and 1972. Since 1948 the debate around and modifications to the water pollution control legislation related to the construction of waste treatment works have focused on several central issues: (1) the proper role and authority of states in managing their environmental affairs, particularly waste treatment; (2) the size contribution or "share" the federal government should provide to state pollution control projects; (3) the distribution formula used to determine how available federal money should be allocated among states, and among municipalities of different sizes; and (4) the criteria or safeguards used to insure efficient use of federal funds.

Over time several things have become clear. The extent and severity of pollution in this country is outstripping any provisions for its abatement and control. The formula for the distribution of funds to states and among various localities brings with it a bias and several disadvantages. Delays in obtaining federal financial assistance have led many states and municipalities to put off pollution control plans or to take initiative in financing their own treatment works. In general total authorizations have steadily increased in recognition of the dimensions of the pollution problem, although actual appropriations have consistently fallen short of authorized levels. The formulas for determining the federal share and the distribution of money to states have been changed repeatedly in an effort to meet all the interests involved. Although federal involvement has increased over the years, some states and municipalities have found it more expedient to pre-finance their treatment facilities rather than wait for federal money before they initiate construction.

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* U.S. Senate, Hearings of the Senate Committee on Water and Air Pollution Control, 84th Congress, 1st Session, Washington, D.C., Government Printing Office, 1964, p. 52.

PUBLIC LAW 660: 1955-56

During the 1955-56 Congressional sessions, two bills (S. 890 and H.R. 9540) were introduced to replace Public Law 80-845 which was about to expire. In both bills the Surgeon General, through the Public Health Service under the Department of Health, Education, and Welfare (HEW), was authorized to investigate pollution sources and causes, and to make grants for research, demonstration projects, and training personnel to operate and maintain treatment plants. S. 890 provided that the Surgeon General would

> from time to time make allotments to the several States, in accordance with regulations, on the basis of (1) the population, (2) the extent of the water pollution problem, and (3) the financial need of the respective States.*

The Surgeon General also was given the broad power to allocate money to interstate agencies on "such basis as [he] finds reasonable and equitable."+

The importance of recognizing and preserving "the primary responsibilities of the States in preventing and controlling water pollution"‡ was emphasized as was the proposed legislation to provide the support and aid in technical research, which was seen as the most effective stimulant to state control programs. HEW officials testified at Senate Public Works Committee Hearings in April, 1955 that

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* Water Pollution Control Act Amendments of 1956, Public Law 660, 84th Congress, Chapter 518, 2nd Session, S. 890.

+ Ibid.

‡ Ibid.

> experience with other health programs has demonstrated the value of matching grants in stimulating States to provide their own resources to do an effective job.

It was argued that federal support was most effective in the form of planning, research, consulting, and technical assistance on tasks which most states could not adequately perform but which were critical to carrying out construction of treatment works.

In line with the argument that matching funds would stimulate state involvement in pollution control, S. 890, Section 5 spelled out a formula for the federal share in control projects:

> The 'Federal share' for any State shall be 100 per centum less that percentage which bears the same ratio to 50 per centum as the per capita income of such State bears to the per capita income to the continental United States (except Alaska), except that (A) the Federal share shall in no case be more than 66 2/3 per centum or less than 33 1/3 per centum, and (B) the Federal share for Hawaii and Alaska shall be 50 per centum, and for Puerto Rico and the Virgin Islands shall be 66 2/3 per centum.
>
> The 'Federal share' shall be promulgated ... on the basis of the average of the per capita incomes of the States and of the continental United States for the three most recent consecutive years for which satisfactory data are available from the Department of Commerce.

In other words, each state received a share of money based on its average per capita income. The exact percent of project costs that the federal government would bear was figured on the ratio of the state's average per capita income to the average per capita income of the nation. No state, however, was to receive a share more than 66.6 percent or less than 33.3 percent of the actual cost of the local project.*

H.R. 9540, Section 6, provided direct federal grants to assist municipalities in the construction of sewage disposal facilities, again emphasizing the "established principle of recognizing the primary rights and responsibilities of the States in controlling water pollution." Instead of the construction loans authorized (but never appropriated) in 1948, this bill provided for matching grants to states, municipalities, intermunicipal agencies, and interstate agencies, for the planning and construction of treatment works. Grants were to be limited to 33.3 percent of the estimated "reasonable" cost of construction or $300,000, whichever was smaller. In recognition of the fact that a few large cities needed amounts that would deplete a state's entire allotment, the legislation specified that at least 50 percent of the funds authorized for treatment works were to be directed to communities with a population of 250,000 or less, with priority given to municipalities that had done advanced planning. The then-current administration did not endorse Section 6 and took the position that the costs for treatment should be borne by the users of the service, not by the federal government in the form of grants.+ (Another bill, S. 982, provided for grants of up to 50 percent of the cost of construction.)

The conference and final version of the bills provided two things: for the Surgeon General to make grants for construction of "necessary" treatment works and for a number of more specific criteria for the awarding of grants. Like the original Federal Water Pollution Control Act, no grant was to be awarded unless the project was approved by the appropriate state water pollution control agency and the Surgeon General, and unless it was included in a "comprehensive" pollution program; no grant was to be for more than 30 percent of the estimated reasonable cost or up to $250,000, whichever was smaller, and the grantee had to agree to pay the remaining cost. Applicants had to demonstrate that there would be "proper and efficient operation and maintenance" of treatment works after completion, and treatment operation had to conform to state pollution control plans.[*] In making his decision about allocations, the Surgeon General was instructed to consider the public benefits to be derived from the project, the relation of ultimate costs to public necessity, and the adequacy of provisions for operation and maintenance.[+]

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* Let x_i = per capita income for state i

x = national average per capita income

$r = 100 - \frac{x_i}{x} \cdot 50$, if

f = "Federal share" in percentage

$f = r$, if $33.3 \leq r \leq 66.6$

$f = 33.3$, if $r < 33.3$

$= 66.6$, if $r > 66.6$

+ Congressional Record, June 13, 1956, p. 10240 ff.

Fifty percent of appropriated grant sums were to be allotted to states on the basis of the ratio that the population of each state bore to all the population in all states.

The other 50 percent of appropriated funds was to be allotted to each state based on a complicated ratio formula. Each state would receive an allotment determined by dividing the per capita income of the entire United States by the per capita income of each state, adding all 50 quotients so derived, and determining the ratio that each state's quotient bore to the total of the quotients.[‡] Of the $50 million authorized by the Act, 50 percent of the appropriations

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[*] *Ibid.*, Section 6(b)(3).

[+] *Ibid.*, Section 6(c).

[‡] Let x_i = per capita income for state i

x = national average per capita income

y_i = population of state i

s = the state fraction of appropriation grant sum

$$s = 50 \frac{y_i}{\Sigma y_i} + 50 \cdot \frac{(x/x_i)}{\sum_i (x/x_i)}$$

were to go to municipalities of 250,000 or less.* "Construction" was defined to include preliminary planning, engineering and feasibility studies, and improvement or extension of treatment works.+

The 1955-56 sessions also were presented with a dozen bills providing for the amortization by industry at an accelerated rate of 60 months of the cost of industrial treatment works for tax purposes, provided the facilities were installed on the basis of demand from local governmental bodies and that the facility was part of an overall program for pollution control. Municipalities had complained that industrial wastes was one of the problems they could not handle through their ordinary residential treatment works. None of these bills, however, were incorporated into Public Law 660.

FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS: 1961

In 1961 the major changes made in the Federal Water Pollution Control Act were to increase the annual amortization of funds and to raise the ceiling on maximum grants to a single project. The Amendments of 1961 increased the annual amortization for construction grants on a graduated scale from $50 million in fiscal year 1961 to $80 million in fiscal year 1962, $90 million in fiscal year 1963, and $100 million for fiscal years 1964-1967.‡ Again, 50 percent of the appropriated funds were earmarked for cities of 125,000 or under. Maximum grants were increased from 30 percent or $250,000, whichever was smaller, to 30 percent or $600,000, whichever was smaller.**

Several other features were added to the Act. A project serving more than one municipality could be funded by applying the grant formula to each community's portion of the project as if it were a separate project. The sum of the maximum grants or $2.4 million, whichever was smaller, was to be made until all applications were funded which met the regulations in effect prior to the Amendments and which were filed with the appropriate state agency during the first twelve months after enactment of the 1961 Amendments.

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* Public Law 660, Section 6(d).

+ Ibid., Section 6(e)

‡ Federal Water Pollution Control Act Amendments of 1961, Public Law 87-88, 87th Congress, H.R. 6441, July 20, 1961, Section 5(d).

** Ibid., Section 5(a).

This Act further provided that all money allotted to states which remained unobligated for six months beyond the 18-month allotment period, could be reallocated to states with an excess of approved projects.* The administrative agent of the Federal Water Pollution Control Act, as amended, was changed from the Surgeon General to the Secretary of Health, Education, and Welfare.

1966 AMENDMENTS: THE CLEAN WATER RESTORATION ACT

During the 1966 session of Congress, debate over the Federal Water Pollution Control Act Amendments centered on the formula for granting federal money to local projects. The testimony at hearings on the large number of bills submitted to amend the Federal Water Pollution Control Act presented an enormous amount of data documenting the increasing demand and critical need for pollution control projects and the flaws and biases of the existing legislation.+ Witnesses described how the 30 percent limit on grants discriminated against both the largest communities and the smallest towns. A needs survey conducted and presented by the Conference of Sanitary Engineers showed that 70 projects in the current backlog of applications would qualify for grants over $600,000 but under $1 million, for a total of $49.6 million if the ceiling for grants were $1 million. Forty other projects would qualify for over $1 million but under $2 million, for a total cost of $183.8 million if the ceiling were $2 million. Eighteen proposed projects were so large that 30 percent of their cost would be $2 million, with a total cost of $255 million. On the other hand, many small towns could not even qualify for maximum grants on the basis of their population counts, nor did they have the capability to finance treatment works on their own.‡

The slowness in receiving federal grants was repeatedly mentioned as a deterrent, both because municipalities delayed construction in the hopes of eventually receiving federal dollars, and because even approved projects could experience lag times of nearly two years. A number of witnesses stressed the importance of allowing swifter reallocation of monies that were unused.

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* Ibid., Section 5(c)

+ Hearings, U.S. Senate Committee on Public Works, May 19, 1965.

‡ Ibid., p. 89

The size of the pollution problem prompted the introduction of a large number of bills aimed at easing the costs of municipal financing of treatment works. Again on the basis of the burden industrial wastes placed on municipal systems, 66 bills were filed to allow a tax deduction for construction costs of treatment facilities. Another dozen was filed to provide money to help retire municipal bonds. There was also interest in providing money to help train people for the efficient operation and maintenance of new facilities. Debate on several bills during hearings raised the idea of reimbursing states for pre-financing of treatment works.

The bills which eventually became Public Law 89-753 initially authorized increasing the authorization for construction grants to $150 million in 1967, up to $1.25 billion in 1971.* Again at least 50 percent of the first $100 million appropriated was to go to municipalities of 250,000 or less.

The general allotment formula to states was the same: the first $100 million appropriated in a fiscal year was to go to states on the basis of population and per capita income weighted equally; sums appropriated above $100 million were to be allotted on a straight population basis with a 10 percent incentive for regional planning of projects. State allotments were usable for the reimbursement of state or local money used prior to June, 1971 and after June, 1966 for projects built without federal assistance (if approved) or with less than the federal share allowable if sufficient funds were available.

The grant allocation formula was changed substantially in this law with a number of built-in incentives attached. The federal government was committed to provide 30 percent of the cost of treatment works if the state provided 25 percent of the cost. The federal share would be increased to 40 percent if the state picked up 30 percent of the cost. If the state had adopted enforceable water quality standards for the waters the treatment project affected, the federal share would increase to 50 percent if the state only contributed 25 percent. Again the criteria established in the 1961 Amendments for selecting projects remained the same, with emphasis on the state determination of priority. River basin plans were eligible for a 50 percent federal share. The ceiling on individual projects was eliminated, and there was a provision included for loans of up to $250 million.

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* Clean Water Restoration Act of 1966, Public Law 89-753, 89th Congress, S. 2947, November 3, 1966, Title II, Section 205.

The committee report on the proposed Amendments stressed once again the need for tax incentives to industry to treat their own wastes. The existing Act contained a provision for a 7 percent investment credit for the acquisition of air or water pollution facilities, which was retained in the Amendments with the provision that facilities met federal and state specifications.*

WATER QUALITY IMPROVEMENT ACT: 1968

In 1968 the grant system was altered to include contracts for up to 30 years to pay the federal share of construction costs. Contracts differed from grants in that they provided a loan to cities which could be issued more quickly than a grant. The federal share could also be eventually recovered. The allotment of these contracts remained the same as grants. The monies available for contracts was to be calculated according to the ratio of the population of each state to the population of all the states, with 50 percent of the first $100 million appropriated to go to cities of 250,000 or less. The contracts could be used to pay off municipal bonds which had been used to pay for treatment works. The Act also approved one-time grants for improving the operation of treatment works, on which construction was initiated after passage of the Act. These grants were not to exceed 25 percent of the cost of operating such treatment works, and in no event were to be over 50 percent of the cost of improving operation during a 12-month period. The authorization for this grant program was $25 million.

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* S. 2857 proposed to increase the tax credit to 14 percent, but it was not acted upon. See Congressional Record, 89th Congress, October 17, 1966, p. 27247.

WATER QUALITY IMPROVEMENT ACT: 1970

In 1970 a variety of bills was presented to increase the federal share and the total and annual authorizations for pollution treatment programs. The Administration bill (S. 3472) estimated that $1 billion federal input was sufficient to cover both the backlog and the increasing needs until 1974. This bill also proposed to reimburse states for prepayment from current appropriations, and a companion bill suggested an Environmental Financing Authority to be managed through the Treasury Department to assist states and localities in borrowing funds they could not obtain through grants. The allocation of funds was to be made on the basis of a new formula which considered population and the severity of local pollution conditions. Sixty percent of the federal funds was to be allocated by population and income; 20 percent was to go to those states which paid at least 25 percent of the cost of all assisted projects, distributed on a population basis; and 20 percent was to be allocated on the basis of the severity of the water pollution problems and the local ability to use funds for basin-wide plans. This last 20 percent was considered "discretionary money" to offset the needs of especially large projects; first priority would go to reimburse states that had pre-financed plans. (The 1966 Amendments had encouraged a number of states and localities to pass bond issues or arrange other means to finance the federal share of costs in anticipation of reimbursement, and by 1969 over $300 million in backlog payments was due.*)

Another bill, S. 3687, challenged the Administration estimate of needs and proposed to authorize $2.5 billion a year for six years. The formula in this bill was similar to the earlier 1955 bill with the federal share being 100 percent minus the complicated percent calculated from ratios of per capita income in individual states to the entire country. At the time, only 16 states were providing the matching shares to raise the federal share above 30 percent.

The Amendments of 1970 as finally passed contained Title I -- the Water Quality Improvement Act -- which made few changes in the sections related to construction grants for waste treatment works. The federal government's commitment to make grants or contracts related to training students "to enter an occupation which involves the design, operation, and maintenance of treatment works, and other facilities whose purpose is water quality control" was expanded by the stipulations in a newly added section (Section 16).

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* Senate Public Works Committee Hearings, Subcommittee on Air and Water Pollution, April 20, 1970, p. 250.

The 1970 Amendments (Title II) also replaced the Federal Water Pollution Control Administration with the Federal Water Quality Administration. Authorizations remained at the level voted in 1966, or $1 billion for the fiscal year ending June, 1970 and $1.25 billion for the fiscal year ending June 30, 1971.

PUBLIC LAW 92-500: 1972

The next major overhaul of the Federal Water Pollution Control Act came in 1972. Title II, called "Grants for Construction of Treatment Works," expanded the purposes of the Act and specified goals related to new technology (including reclamation and recycling). Although federal financial assistance is not limited to this revised Act or its predecessors (HUD, EPA, and FHA, for example, all have authority to grant funds for treatment plants), the new Act has taken precedence over most other funding sources. Authorizing legislation for other grant sources have not been considered in this discussion.

Several broad new conditions were placed by the 1972 Amendments on the allocation of grants after June 30, 1974, including that:

- Projects provide for the application of best-practicable waste treatment technology over the life of the works;

- Projects will consider and allow for the application of new technology for reclaiming or recycling water; and

- Each sewer collection system discharging into the treatment works is not subject to excessive infiltration.

The Amendments as finally adopted and passed over the President's veto provide for 75 percent federal grants for facility construction with no specified state participation required. (The Senate bill provided for a 70 percent federal grant if the state participated with a 10 percent grant; the House bill provided for a 75 percent federal grant if the state participated with a 15 percent grant or loan. No state participation would have led to federal grants of 60 percent under either bill.) The Amendments further provide for an Environmental Financing Authority to assure municipal access to funds to finance its share of project costs and for the allocation of funds among states according to need for treatment plant construction.

APPENDIX B

CURRENT FEDERAL GRANT PROGRAM

FACILITY PLANNING

As explained in the text, the three-step funding procedure includes

Step 1 facilities plans and related studies;

Step 2 construction drawings and specifications and sewer system rehabilitation if required; and

Step 3 building of an operable treatment works.

Grants may be awarded for Step 1, Step 2, Step 3, or projects that combine Steps 2 and 3. Step 2, Step 3, or Step 2/3 projects, however, can only be funded if facilities planning (Step 1) requirements have been satisfied.

These requirements include:

- treatment works description;
- complete waste treatment system description;
- sewer system evaluation;
- cost-effectiveness analysis;
- copy of permit to discharge;
- comments of agencies with reference to A-95 and 208 planning requirements;
- public reactions;*
- legal, financial, and managerial capabilities statement; and
- civil rights statement.

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* There are certain explicit public participation requirements.

For Step 2, Step 3, or Step 2/3 grants from funds authorized for any fiscal year beginning after June 30, 1974, best-practicable wastewater treatment technology must serve as the basis for planning and design unless application of best-practicable treatment would not meet water quality standards. In that case the plan must provide for meeting those standards.

GRANT APPLICATION AND APPROVAL

Grant approval requires the determination

(a) that a facilities plan has been approved before award of Step 2 or Step 3 grant funds.

(b) that proposed works are in conformity with any approved 303(e) basin plans.

(c) that proposed works are state certified as to priority.

(d) that grant award will not cause the total of all grants to that state's applicants to exceed the state's allotment.

(e) that the applicant agrees to pay all non-federal project costs. (Grant payments are made directly to the municipal authority constructing the treatment works and it is a responsibility of that authority to collect any state contribution.

(f) that a copy of the NPDES permit be provided.

(g) that user charge and industrial cost recovery regulations will be complied with.

(h) that the proposed site will be available and that the Relocation and Land Acquisition Policies Act of 1970 as well as other federal regulations or statutes will be complied with.

(i) that NEPA environmental impact assessments have been performed.

(j) that the Civil Rights Act of 1964 has been complied with.

(k) that satisfactory provision has been made to assure proper and efficient operation and maintenance of the facility and that the state will have an effective operation and maintenance monitoring program to assure compliance with applicable permit and grant conditions.

(l) that if the project includes sewage collection system work, such work is either for replacement or major rehabilitation of an existing sewer system and is necessary to the performance of the wastewater treatment works, or is for a new sewer system in a community in existence on October 18, 1972, (where the bulk of the expected flow in the system will originate from the community habitation in existence on that date) with sufficient existing or planned capacity to adequately treat such collected sewage.

(m) that fiscal year 1975 or later grants are for best-practicable wastewater treatment technology over the life of the works and that the applicant has allowed (as appropriate and to the extent practicable) for the later application of technology to eliminate the discharge of pollutants.*

(n) that project costs do not include: costs allocable to treatment of pollutants in industrial wastes unless the applicant is required to remove such pollutants introduced from non-industrial sources; costs allocable to treatment of wastes from federal government activities that another federal agency has agreed to pay; or the unexpended balance of the amounts retained by the applicant for future reconstruction and expansion pursuant to industrial cost recovery regulations, together with interest earned thereon.+

(o) that initiation of construction has not occurred.

(p) that the applicant is the designated 208(d) area wastewater treatment management agency if one has been designated.

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* Step 2 grants for projects to be funded by fiscal year 1975 or later money will only be approved for wastewater treatment works to be designed in accordance with best-practicable treatment regulations.

+ This could be interpreted to mean that there should be no differential subsidy between industrial and non-industrial municipalities. The implications of the presence of significant industrial load in a community are discussed in Section 4 of this report.

(q) that the proposed wastewater treatment works will comply with all federal and state environmental laws, including the Clean Air Act.

(r) that each sewer system discharging into the wastewater treatment works is not and will not be subject to excessive infiltration/inflow. The determination that this is the case requires an infiltration/inflow analysis according to guidelines (including a cost-effectiveness analysis of costs of eliminating the infiltration/inflow conditions and of transporting and treating the infiltration/inflow) and, when necessary, a sewer system evaluation survey followed by rehabilitation of the sewer system.*

(s) that a sewer use ordinance prohibiting any new connections from inflow sources into the sanitary sewer portions of the sewer system and ensuring that new sewers and connections are properly designed and constructed will be enacted and enforced.

(t) that industrial pre-treatment requirements will be met.

PROJECT COSTS

Allowable costs include:

- salaries, benefits and expendable material incurred by grantee;
- costs under construction contracts;
- professional and consultant services;
- facility planning;
- sewer system evaluation;
- feasibility and engineering reports;
- certain relocation costs connected with land acquisition;

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* Such rehabilitation work may be approved as Step 2 work; it may also, under certain conditions, proceed as Step 3 work, although this is expected to occur infrequently.

- costs of complying with NEPA;
- preparation of drawings, specifications, and estimates;
- landscaping;
- construction supervision;
- removal and relocation of utilities;
- materials for the project;
- laboratory supplies needed to initiate plant operations;
- operation and maintenance manual preparation; and
- project identification signs.

Costs not allowable include:

- basin or area planning not directly related to the project;
- bonus payments not legally required for early project completion;
- personal injury compensation or damages;
- fines and penalties;
- unapproved costs;
- interest on bond to finance project;
- ordinary operating expenses of local government; and
- site acquisition, except for land acquired after October 17, 1972, that will be an integral part of the treatment (e.g., land for spray irrigation of sewage effluent, but not land for oxidation ponds) if approved by EPA.

APPENDIX C

ISSUES IN FISCAL FEDERALISM

Starting with its early history, the United States has a relatively decentralized fiscal structure with over 80,000 government units providing services and raising revenues. Strong arguments support this multi-unit, multi-level form of government.* Undoubtedly the most important theoretical argument is a decentralized fiscal structure provides a means by which individual preferences can be honored. Since each local government unit is able to choose its own level and mix of services, a variety of public service-tax bundles are provided that reflect some of the variety of individual preferences in tastes, in the size and composition of the family, in income, and in the price of the public service. This variety of public service-tax bundles theoretically allows individuals to choose a location that satisfies their own demands. However, determination of level of services and allocation of costs is by majority vote of the members in any given unit, and consequently minority interests can be protected only if these minorities are concentrated in a few districts or if a higher level of government intervenes to protect their interests. An additional argument in favor of a system of many small units is that those who benefit from a service should pay for it. The benefit area of many services is relatively small, such as a police or fire station. Thus, the argument runs, the unit of government that is responsible for providing the revenues should also be small. To complicate matters, however, there is often a non-equivalence of benefit areas for the various government services demanded in a locality and special-purpose districts are frequently organized.

In place of a complex system of overlapping special-purpose districts, various services have often been consolidated into a simpler set of local government units, although the problem of overlapping districts remains in most urban areas. Consequently, the benefits from services provided in one district often spill over into surrounding districts. This can lead to an undersupply of the service because the groups who bear the entire cost and who determine the level of service do not receive all the benefits. When comparing the cost of the service to the benefits derived, they will not include the benefits received by other members of society who are outside this specific jurisdiction. Consequently, the value of the benefits is underestimated relative to the cost. In a like manner these spill-overs can lead to an oversupply of a negative externality such as water pollution resulting from a waste discharger located on the edge of a town. Therefore, the first reason for intergovernmental transfers is to help correct this problem by allowing those outside the jurisdiction to contribute to the provision of a service they desire, or to the removal of a negative externality.

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* For a complete listing of these references, see the last page of this appendix.

There are other reasons for the non-equivalence of benefit and cost areas. Individuals and businesses are mobile, often taking benefits with them. Frequently people leave the jurisdiction in which they were educated and thus another area benefits from their skill and knowledge. In addition, many jurisdictional boundaries were determined many years ago. With changing demands for the type of services provided, new technology used in their provision, and new patterns of development, benefits and costs frequently spill over from one jurisdiction to another. These new factors lead to a non-optimal supply of public services that can be mitigated against by intergovernmental transfers.

In addition to the non-equivalence of benefit and cost areas, a second reason for having intergovernmental transfers, especially from the federal level, is to encourage the provision of certain "merit goods" such as education that are considered desirable by society. A third reason is the need for the federal government to effect some redistribution of income. Instead of approaching redistribution directly in terms of some form of guaranteed income, the federal government has subsidized the provision of various goods such as low-income housing. In this way the poor receive more of certain goods that the government feels they should receive, but not of all goods.

Grants from federal and state governments may also be provided in order to equalize the position of local fiscal units. These grants are motivated by the need to correct inter-individual differences and by the desire to correct locational inefficiencies. Some jurisdictions may be hard pressed to provide certain services essential for business because of the composition of their tax base. These differences in ability are undesirable in that they distort locational decisions, especially of businesses, through differences in the tax rate.

TYPES OF GRANTS

Grants can be categorized according to three characteristics. First, the grant can contain matching provisions which require the recipient jurisdiction to match each dollar of federal funds with a certain amount of its own money. Some grants do not contain any matching provision and thus use other criteria to determine the size of the transfer. Second, a grant can be restricted to specific expenditures, frequently called a categorical grant; or it can be unrestricted, also called a general or block grant. Third, grants can also be based on some measure of fiscal capacity and/or on a measure of the amount of service which needs to be provided such as the size of the target population.

The matching provision lowers the relative price of the public service. With a matching ratio of 50:50, the local government gets $1 worth of service for each 50¢ of its own money it spends. This reduction in the relative price will normally result in an increase in the amount of public goods provided. The additional amount purchased will depend in part on the price elasticity of the good in question. There is also an income effect because with the grant the community has more money to spend in total. Therefore, there is likely to also be an increase in the amount of private goods purchased by the recipient community.

Grants with no matching provision are equivalent to an income transfer to the jurisdiction. Even though the grant is given to the local government, it can result in a tax cut that allows increased private consumption because the community always has the option of simply replacing its own funds with the grant money. Therefore, if the goal of a grant is to encourage the provision of more public goods, as opposed to private goods, then a matching grant is more effective.

With a non-matching grant there is little difference between a categorical and a block grant (as long as the categorical grant is less than what would be spent anyway). This is due to the fact that they both are an increase in income. If the non-matching grant is limited to certain expenditures (categorical), then the relevant comparison (with regard to the goal of increasing the provision of this public good) is between the amount of expenditures without the grant and the size of the grant. With a matching provision, the categorical grant lowers the price of that specific good relative to all other public goods and all private goods. Thus, if the provision of a specific public good is to be encouraged, as opposed to all public goods, a matching categorical grant is more effective than a matching block grant. Categorical grants can be limited to the provision of a certain service or to certain inputs for a certain service such as capital investments in municipal wastewater treatment.

Even with a categorical matching grant a community may decide to use only part of its prior expenditures to meet the matching provision and to use the rest to increase expenditure on other public goods or to reduce the tax rate. Such substitution depends on the relative price and income elasticities. Some grant programs have tried to insure that all federal money is directed toward an increase in the level of service. An example is the Senate version of the Education Amendments of 1972 which provide for a program where the federal government pays 50 percent of the increased amount of state scholarship grants provided over a base year.*

The third characteristic of grants is the use of measures of fiscal capacity and/or need. In many cases per capita income is used on the assumption that people with less income are less able to provide themselves with public services. Perhaps a better measure is of the type developed by the Advisory Commission on Intergovernmental Relations.+

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* Hartman, R. W., "Higher Education Subsidies: An Analysis of Selected Programs in Current Legislation," The Economics of Federal Subsidy Programs, Part 4, Joint Economic Committee, Congress of the United States, August 28, 1972, p. 481.

+ Advisory Commission on Intergovernmental Relations, Measuring the Fiscal Capacity and Effort of State and Local Areas, Washington, D.C., Government Printing Office, 1971.

They argue that it is the amount of tax revenue available, not the average income, that is relevant. For each kind of state and local tax a rate is determined which, if applied throughout the nation, would produce an amount equal to the actual yield of that tax. For each state the potential yield of each type of tax is estimated at this nation-wide rate; and the potential yields are summed to arrive at its total tax capacity. This same approach has been applied to non-tax sources of incomes, such as fees and charges, to yield a total revenue capacity for each state. The actual revenues collected in each state have been compared to this revenue capacity to provide a measure of the relative tax effort.

It is important to remember that this is a measure of the government's effort, not a measure of the size of the burden on its citizens, although the two will be somewhat related. The study of tax incidence is complicated and presently filled with disagreements although there is agreement that certain taxes are shifted from those who initially pay them to someone else. For example, the bulk of the sales and excise taxes collected from producers, wholesalers, and retailers are passed along to the buying public in the form of higher prices or a specific charge. In areas with a large number of tourists, revenue can be raised through taxes on hotel and motel accommodations, restaurant meals, and amusement. Thus, it is not valid to simply assume that states making large efforts are states with a heavy burden on local residents.

Financial capacity measures have played a role in many state programs of aid for education. As of 1966-67, approximately 37 percent of all state aid and 69 percent of all state educational aid involved some adjustment for local capacity differences.* In most cases the property base rather than the potential yield of all revenues is used to measure capacity. School expenditures rather than total local expenditures are used to measure effort. In 1968, 25 federal grant programs disbursed funds with some allowance for differences in fiscal capacity. Of these, seven were grant programs for public facility construction and 18 were for the provision of public services.+ Personal income is always the measure of fiscal capacity used for federal grants. However, the Advisory Commission on Intergovernmental Relations study shows that for certain states there is a wide divergence between per capita income and revenue capacity. For 24 states, per capita income under-indicates relative revenue capacity by at least 5 percent; and for five of these it under-indicates from 24 to 37 percent. Likewise for ten states, per capita income over-indicates relative revenue capacity by over 5 percent.

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* Ibid., p. 33.

+ Ibid., p. 11

The common measure of effort is to compare taxes to personal income. The current revenue-sharing formulas include this type of measure of effort. However, for some states this also is a poor measure of effort. For ten states the traditional taxes/income measure under-indicates relative revenue effort by over 5 percent; and for 18 states it over-indicates the revenue effort.

A related issue is a measure of need. This is usually established in terms of target population (school age children, total population, families in poverty, etc.). Almost all HEW grants include a measure of target population. One problem with this is that different members of the same population set may have different needs. For example, it requires more resources to provide a given level of housing in the northeast than it does in the south simply because of differences in climate. In addition, there may be differences in the costs of providing a given level of service. Most of the housing subsidy programs require a certain quality of construction and size of unit, and then subsidize or take over the mortgage, thus implicitly allowing for differences in costs.

The equalizing effectiveness of using measures of fiscal capacity and/or need to allocate funds is often severely diluted by placing a limit on the total amount of funds any community may receive. This is a technique used by various states in their programs to subsidize education, where expenditures are matched up to 110 or 125 percent of the state average. If a community spends money in excess of the amount matched by the grant program (a closed-end matching grant), then the grant no longer has a price effect but only an income effect.

These various characteristics can be used in combination to achieve specific goals or to correct certain problems. The type of grant best suited for correction of spill-overs is a categorical grant aimed at that specific service, with a matching provision. Measures of need are not included. The matching rate should be equal to the ratio of external benefits (benefits accruing to those outside the providing jurisdiction) to total benefits. In other words, those outside of the jurisdiction providing the service pay their share of the cost. If the purpose of the grant is to encourage the provision of merit goods, then a matching non-need related grant is appropriate. If all public goods are considered to be merit goods, then this could be a block grant; otherwise, it should be categorical. In order to equalize the fiscal capacities of jurisdictions, a block grant with a need measure can be used. Equalization plus encouragement of the provision of merit goods can result from the use of a categorical grant with a measure of need.

The use of grants by the federal government to stimulate the provision of public services dates back to early land grants given to encourage the building of schools. Monetary grants date back at least to 1879 when a program was started to provide books for the blind. These early grants were usually offered in equal per capita amounts to each state, subject to a dollar-for-dollar matching formula. During the Depression, a measure of financial need was added to the formulas used, such as that for the emergency relief program and the Social Security Act of 1935. The enactment of the School Lunch Program in 1946 introduced the use of a variable matching ratio. This had already been used by some states in their grants to local schools. The 1948 Amendment to the Hill-Burton Act provided for separate aid for innovation and experimentation.

The amount of funds and the number of grants has increased significantly in recent years. In 1960 federal grants totaled $19 billion and in 1970 they were $23.9 billion, with an estimated $45 billion in 1973. There appears to be a continuing trend towards more centralized revenue collection combined with local expenditure decisions. In 1940, 11.6 percent of state revenues were in the form of federal grants, and 23.6 percent of local revenues were in the form of state grants. By 1970 this had grown to 22.1 percent of state revenues from federal grants and 32.7 percent of local revenues from state grants, with only about 3 percent of local revenues coming directly from federal grants.

In addition to this growth in amount of aid, the pattern of cost sharing has changed. Federal shares have tended to increase, but the ratios have also become more diverse. Where once the accepted ratio was 50:50, the federal government has paid up to 90 percent of the cost of Neighborhood Youth Corps projects, Adult Basic Education, and Community Action Programs. (Of course, revenue-sharing is equivalent to a federal matching percentage of 100 percent.) The matching ratios have been applied as if they were a precise tool for the fine tuning of a public decision. Variable ratios have been used to encourage organizational changes in government or the provision of services considered to be of top priority. Federal aid for college construction is one-third, unless it is construction of a facility for a community college in which case the federal government pays 40 percent. Under the highway trust fund grants for certain primary and secondary roads were 50 percent, but for the interstate system the grants were 90 percent. There has also been an increased emphasis on planning. Under the 1964 Urban Mass Transportation Act, federal funds would finance up to two-thirds of the net project cost if there was an urban transportation plan; otherwise grants of one-half of costs were allowed. This has been coupled with direct professional consultation and technical help to states and localities.

ALLOTMENT FORMULA

After the general characteristics of a grant program are established, the allotment formula must be established. The actual amount of funds available to any jurisdiction is based on the allotment formula used. In addition, there may be matching requirements. The most common allotment formula is one based on the size of the target population, such as total population, school age children or welfare recipients, for example:

$$A_i = a_0 + a_1\left(\frac{P_i}{P_t}\right)$$

where A_i = allotment for the ith state

P_i = target population in ith state

P_t = total target population in nation as a whole

a_0 = a constant to cover administrative costs, usually very small

a_1 = a constant set by legislation.

Population is a crude measure of need for it does not consider differences in costs, nor does it consider differences in capacity. However, it is easy to apply and is used in the majority of HEW grants. In addition, the majority of grants use a uniform matching rate. The matching rate varies between programs, running from 33.3 percent for higher education facilities (which are not part of a community college) to 90 percent for Adult Basic Education and the National Teachers Corps. In some cases the allotment formula includes a measure of per capita income in addition to the target population. This is a more refined measure of need. One example is the allotment to a state for basic support of Vocational Rehabilitation:

$$A_i = a_1 \frac{P_i \left[1.0 - 0.5 \left(\frac{y_i}{y}\right)^2\right]}{\Sigma_j P_j \left[1.0 - 0.5 \left(\frac{y_j}{y}\right)^2\right]}$$

where A_i = allotment to ith state

a_1 = constant set by size of appropriation

P_i = population in ith state

y_i = per capita income in ith state

y = per capita income for the United States.

Thus as a state's per capita income rises in relation to the national average, its allotment decreases. With this type of allotment formula, the state with the lower per capita income is eligible for more money, but if the matching rate is uniform, this state does not necessarily receive more help in reaching any level of expenditures. Figure 9 illustrates this.

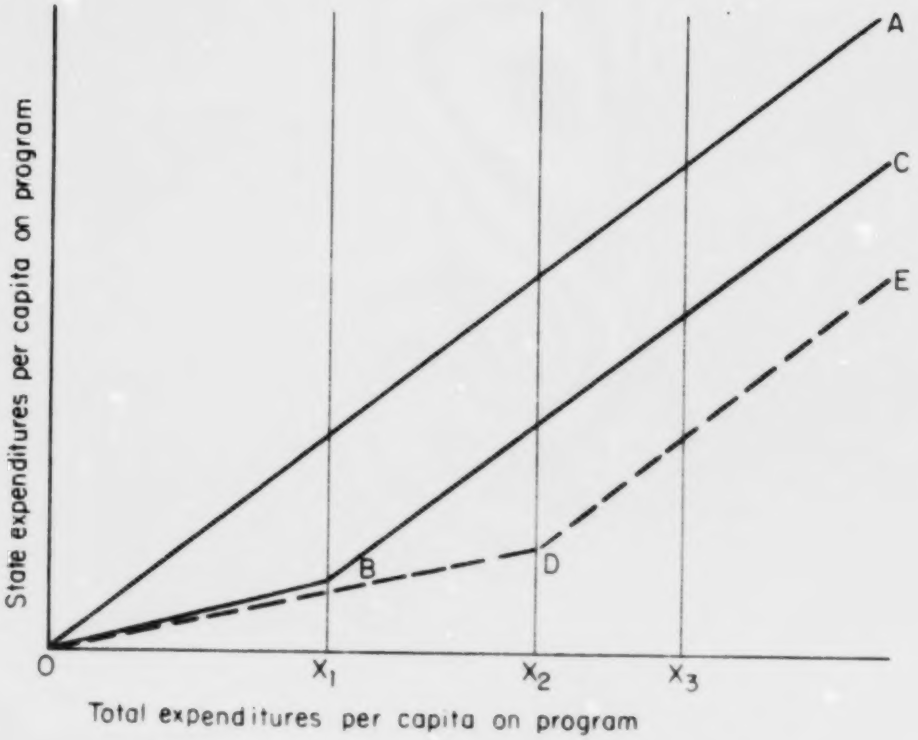

Figure 9 Operation of allotment formula based on per capita income with uniform matching grant

In Figure 9

OA = budget line with no aid,

OBC = budget line of wealthier state with matching grant up to OX_1;

ODE = budget line of poor state with matching grant up to OX_2.

If both states provide X_1 or less service, they face the same relative price; if both states provide between X_2 and X_1 service, the wealthier community faces a higher relative price; and if both states provide X_2 or more service, they both face the same relative price, although state expenditures of the poorer state is less than that of the wealthier state; if operating between X_1 and X_2, the grant to the wealthier state is equivalent to a non-matching grant whereas that to the poorer state is a matching grant; and if they are operating at X_3, then it is equivalent to a non-matching grant for both.

An alternative approach is to have the allotment based on the relative target population, with a matching ratio which varies with the relative income of the state. This is the approach used in the Library Services and Construction Act. The allotment to the ith state is:

$$A_i = a_0 + a_1 \left(\frac{P_i}{P_t}\right) .$$

The federal share in matching to the ith state is:

$$F_i = 1.0 - 0.5 \left(\frac{y_i}{y}\right)$$

As a result of this formula the poor state is not eligible for any more funds than the wealthier one is, but the relative price is lower. Thus there is a greater incentive to the poorer state to use the funds available to it.

Several of the welfare and public health aid programs include per capita income in both the allotment and the matching ratio formulas. For these particular programs, per capita income is a measure of both need and fiscal capacity. As an example, in the Hill-Burton Hospital facilities construction grant, the relative income factor is weighted:

$$A_i = a_1 \frac{P_i \left[1.0 - 0.5 \left(\frac{y_i}{y}\right)^2\right]}{\Sigma_j P_j \left[1.0 - 0.5 \left(\frac{y_j}{y}\right)^2\right]}$$

and

$$F_i = 1.0 - 0.5 \left(\frac{y_i}{y}\right) .$$

The squaring of the income factor (y_i/y) is meant to be a measure of need. By incorporating fiscal measures in both the allotment and the matching ratios, it is possible to provide incentives for low-income states to provide the same level of service as high-income states, and to do so at less cost to the low-income state.

SHIFT TOWARD BLOCK GRANTS

The Nixon administration has fostered a move towards lumping together existing categorical aid programs into a limited number of broad-purpose grants, thus reducing the merit good and redistributional aspects of many programs while simplifying the administrative requirements. The 1972 Amendments to the Social Security Act have essentially transformed an open-ended matching grant for social services into a population-based block grant. The Manpower Development and Training Act of 1973 consolidated a large number of categorical manpower programs into a block grant.

While it is too early to know the full impact of a shift from categorical to block grants, certain features already are emerging. Most likely there will be a redistribution of funds away from large inner cities. One reason for this is that many categorical grants were focused on problems found almost exclusively in large cities. The objectives of block grants are more general, using broader indices of need. In addition to the question of resources to finance programs, the categorical grant strategy concerned itself with the need to establish new institutions in order to get new services started. Thus under broad block grants we would expect to see a shift away from many of the special programs now supported by categorical grants and toward more traditional forms of expenditures or tax reductions. This has certainly been the case under general revenue-sharing and other block grant programs.

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APPENDIX D

ANALYSIS OF TIME PATTERNS OF EXPENDITURES

This appendix examines the time pattern of attaining the goals of the 1972 Amendments under various assumptions regarding funding levels and construction priorities. The analysis is based on use of the 1973 Survey of Needs and utilizes a model which extends the capacity of the national model discussed in Section 4 to answer the following questions:

1. for a given number of dollars and grant level, how many of the new or modified treatment plants can be built;

2. for a given number of dollars and grant level, how many pounds of BOD can be removed from wastewater streams.

Answering these questions using the 1973 Survey of Needs is a rather straightforward matter although the analysis is complicated slightly for question (2) by the fact that all the records are not complete. The answer to the first question can be obtained by assuming: (1) that the federal government authorizes a given dollar amount for the capital subsidy program; (2) that the money is distributed to the states on the basis of stated need, i.e., the ratio of a state's dollar to the national aggregate; (3) that the grant is to be a given percentage of capital costs (e.g., 75 percent); and (4) facilities are built when grant monies are available.

As discussed in Section 4, assumptions are made to account for the lack of information in the Survey of Needs record. However, as more information is needed for this analysis, not all records are utilized. In fact, only 6,300 of the total 11,000 non-sewer records were utilized in the analysis of this appendix. This is a serious limitation.

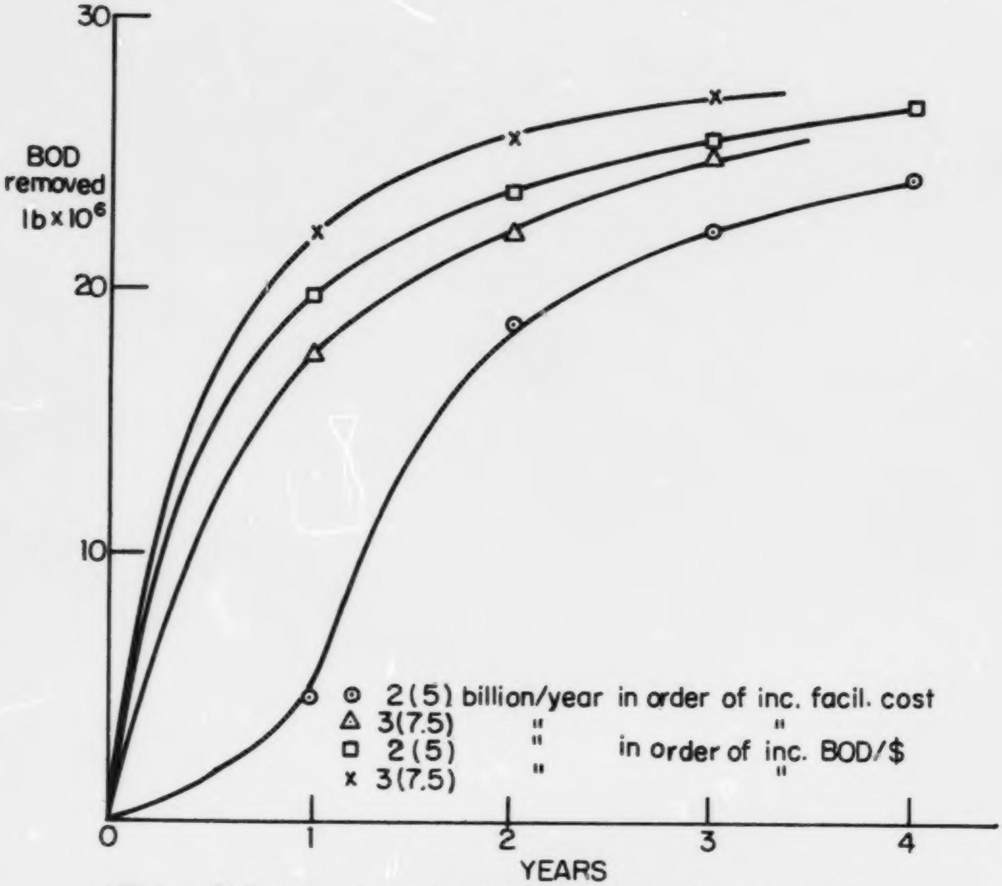
Two alternative construction priorities are examined. The first is that each state will build all treatment plants starting with the least expensive until grant funds are exhausted. Such a procedure provides an estimate of the maximum number of subsidized treatment plants that can be built. The second assumes that each state allocates its share of a priority list based on a BOD removed per facility cost criterion, i.e., grant funds are distributed as a function of pounds of BOD removed per dollar until the monies run out.

Figures 10 and 11 present for the 75 percent capital grant the national time pattern of achievement under two alternative financing patterns of $2 or $3 billion per year for treatment plants only. Based on the 1973 Survey of Needs percentage of treatment to total costs of 40 percent, this would be the equivalent of federal grant expenditures respectively of $5 or $7.5 billion per year.

In all cases the time patterns show decreasing returns after the first year. Tables 16 through 27 present the results disaggregated by states. In each case the tables are for cumulative federal expenditures. Thus, for example, Table 19 represents the results from a cumulative federal expenditure of $6 billion which can represent either 3 years at $2 billion per year or 2 years at $3 billion per year.

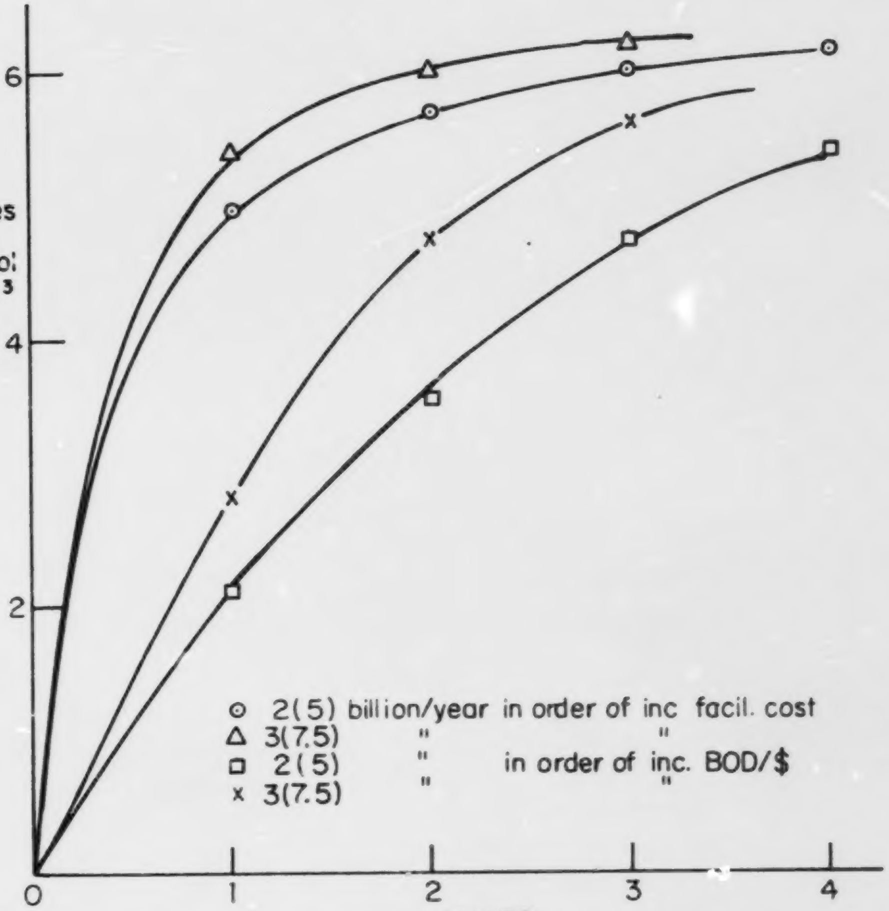
In the model which produces these tables, the cumulative expenditures are assumed to be allotted to the individual states based on the current allotment formula, i.e., in proportion of that state's needs to total national needs. The model produces the state-by-state totals based on a discrete number of treatment plants under the priority of increasing facility cost for Tables 16 through 21 and a priority of increasing BOD removed per dollar for Tables 22 through 27. A result of this discrete process is that the particular expenditure level is not completely exhausted.

This process is basically as follows: let the federal allocation for a particular state be $Y. If the federal cost to build the first N plants in the state priority list is $Z where $Z < Y$ and the federal cost to build N+1 plants is V where $V > Y$, then the totals for that state are based on N plants and the quantity (Y-Z) is not expended.



KEY: a(b) billion/year implies an expenditure of federal construction grant monies of $a billion/year for treatment plants only and a total federal grant expenditure of $b billion year

Figure 10 BOD removal time patterns 75% capital grant



KEY: a (b) billion/year implies an expenditure of federal construction grant monies of $a billion/year for treatment plants only and a total federal grant expenditure of $b billion year

Figure 11 Source control time pattern 75% capital grant

TABLES 16 THROUGH 21

State BOD removals and sources controlled for cumulative federal expenditures of \$2, \$4, \$6, \$8, \$9 billion under the priority of construction in order of increasing facility cost.

Table 16.

REMOVAL IN ORDER OF INCREASING CAPITAL NEED , $ 2000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	56903.	24.99	84	135	17096240.	
2	ALASKA	28312.	4421.	15.62	44	60	8354250.	
3	ARIZONA	265507.	32597.	12.28	58	71	8413500.	
4	ARKANSAS	79763.	34433.	43.17	88	115	12083250.	
5	CALIFORNIA	1574631.	778098.	49.41	311	353	263961504.	
6	COLORADO	178839.	80662.	45.10	101	117	17106736.	
7	CONNECTICUT	46614.	21042.	45.14	18	33	23624224.	
8	DELAWARE	23991.	17423.	72.62	14	16	9121500.	
9	DISTRICT OF COLUMBIA	191233.	0.	0.0	0	1	0.	
10	FLORIDA	365913.	208138.	21.53	74	110	84956048.	
11	GEORGIA	462847.	125870.	27.19	166	210	42549568.	
12	HAWAII	11314250.	23177.	0.20	15	30	22484976.	
13	IDAHO	80404.	4868.	6.05	28	34	3411000.	
14	ILLINOIS	390857.	218447.	57.36	331	359	119816016.	
15	INDIANA	264094.	77798.	29.46	117	148	29033136.	
16	IOWA	312509.	153266.	49.04	245	261	23361712.	
17	KANSAS	119565.	39354.	32.91	99	126	18209232.	
18	KENTUCKY	249093.	150001.	60.22	53	76	31910944.	
19	LOUISIANA	240594.	101046.	42.00	96	130	13927500.	
20	MAINE	105489.	41398.	39.24	59	88	14168250.	
21	MARYLAND	1055872.	27098.	2.57	30	40	27835472.	
22	MASSACHUSETTS	299003.	47831.	16.00	21	38	39524224.	
23	MICHIGAN	281319.	125486.	44.61	94	109	81310320.	
24	MINNESOTA	115466.	61160.	52.97	107	115	28889184.	
25	MISSISSIPPI	113394.	28158.	24.83	56	73	11301750.	
26	MISSOURI	208012.	71885.	34.56	136	151	43373136.	
27	MONTANA	10176.	7486.	73.57	24	30	2697750.	
28	NEBRASKA	321002.	35814.	11.16	106	115	7343250.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225506.	33980.	15.07	48	79	18100496.	
31	NEW JERSEY	895222.	153843.	17.38	83	123	145222240.	
32	NEW MEXICO	78293.	12126.	15.49	11	23	3436500.	
33	NEW YORK	1090653.	215512.	19.76	232	273	228416896.	
34	NORTH CAROLINA	634218.	66526.	10.49	77	122	40875616.	
35	NORTH DAKOTA	33701.	12599.	37.68	48	54	1484250.	
36	OHIO	351287.	162502.	19.09	234	295	101806384.	
37	OKLAHOMA	330071.	58546.	17.74	137	181	26633120.	
38	OREGON	93722.	16580.	24.06	5	6	11225250.	
39	PENNSYLVANIA	634303.	189918.	29.92	316	430	86375824.	
40	RHODE ISLAND	136510.	8210.	6.01	7	17	6955500.	
41	SOUTH CAROLINA	479940.	124507.	25.94	184	249	31467424.	
42	SOUTH DAKOTA	41388.	14951.	36.12	46	53	2104500.	
43	TENNESSEE	510101.	56894.	11.15	48	70	25385952.	
44	TEXAS	621511.	253803.	40.90	246	294	36124848.	
45	UTAH	118026.	11966.	10.14	40	72	9168000.	
46	VERMONT	29278.	5783.	19.75	28	71	6186000.	
47	VIRGINIA	522431.	126288.	20.29	175	200	54508128.	
48	WASHINGTON	233002.	89453.	30.71	53	68	28922960.	
49	WEST VIRGINIA	133908.	63134.	34.33	250	310	17912944.	
50	WISCONSIN	185282.	40798.	22.02	59	79	27035184.	
51	WYOMING	42762.	15271.	35.71	28	34	1538250.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	0.	0.0	0	3	0.	
54	GUAM	25454.	1113.	4.37	2	6	1008750.	
55	PUERTO RICO	250043.	28071.	11.23	21	36	21596224.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16836.	378.	2.25	1	4	457500.	
TOTAL		27927936.	4341346.	15.54	4972	6316	1942943232.	

Table 17.

REMOVAL IN ORDER OF INCREASING CAPITAL NEED , $ 3000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL EOD	EOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	99077.	43.50	99	135	25553152.	
2	ALASKA	28312.	5905.	20.85	41	60	11556000.	
3	ARIZONA	265509.	40186.	15.14	62	71	12509250.	
4	ARKANSAS	79768.	40983.	51.38	99	115	[illegible]	
5	CALIFORNIA	1574681.	1108158.	70.37	327	353	385951232.	
6	COLORADO	178836.	138253.	77.31	106	117	25202960.	
7	CONNECTICUT	46616.	25760.	55.26	22	33	35900208.	
8	DELAWARE	23991.	17423.	72.62	14	16	9121500.	
9	DISTRICT OF COLUMBIA	[illegible]	0.	0.0	0	1	0.	
10	FLORIDA	966618.	276218.	28.36	65	110	[illegible]	
11	GEORGIA	461147.	185103.	40.14	179	210	63737744.	
12	HAWAII	11314250.	11234900.	99.30	18	30	35118720.	
13	IDAHO	80404.	7857.	9.77	30	34	6279000.	
14	ILLINOIS	380857.	284081.	74.59	344	359	176304432.	
15	INDIANA	264094.	98458.	37.28	126	148	44249088.	
16	IOWA	312509.	168033.	53.77	249	261	32443440.	
17	KANSAS	[illegible]	54177.	45.31	108	126	27419952.	
18	KENTUCKY	[illegible]	169530.	68.06	59	76	47063184.	
19	LOUISIANA	[illegible]	120058.	54.31	107	130	20481728.	
20	MAINE	[illegible]	80247.	47.63	69	88	21337456.	
21	MARYLAND	[illegible]	72522.	6.91	33	40	47073712.	
22	MASSACHUSETTS	[illegible]	50640.	16.94	25	38	[illegible]	
23	MICHIGAN	281519.	177352.	63.04	101	109	[illegible]	
24	MINNESOTA	115466.	69171.	59.91	112	115	41422400.	
25	MISSISSIPPI	113596.	43586.	36.79	61	73	17586000.	
26	MISSOURI	218012.	93971.	45.18	142	151	64913856.	
27	MONTANA	10176.	8474.	83.27	26	30	4430250.	
28	NEBRASKA	[illegible]	46023.	14.34	109	115	11187750.	
29	NEVADA	[illegible]	5665.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225506.	42771.	18.97	56	79	28015456.	
31	NEW JERSEY	[illegible]	[illegible]	23.37	94	123	[illegible]	
32	NEW MEXICO	78243.	19111.	24.41	14	23	5485250.	
33	NEW YORK	[illegible]	[illegible]	[illegible]	246	273	[illegible]	
34	NORTH CAROLINA	[illegible]	164681.	26.12	89	122	61720272.	
35	NORTH DAKOTA	33700.	21016.	62.37	50	54	2234250.	
36	OHIO	[illegible]	227834.	27.94	256	295	[illegible]	
37	OKLAHOMA	330671.	90295.	27.26	155	181	[illegible]	
38	OREGON	[illegible]	[illegible]	100.00	6	6	22175248.	
39	PENNSYLVANIA	634603.	274187.	43.30	351	430	129028080.	
40	RHODE ISLAND	[illegible]	8653.	6.37	4	17	12055500.	
41	SOUTH CAROLINA	472540.	[illegible]	30.33	203	249	47436304.	
42	SOUTH DAKOTA	[illegible]	21594.	52.17	49	53	2973750.	
43	TENNESSEE	[illegible]	[illegible]	13.76	54	70	36504664.	
44	TEXAS	620519.	429217.	69.17	273	294	54431424.	
45	UTAH	[illegible]	18851.	17.65	47	72	13648500.	
46	VERMONT	29278.	8054.	27.51	36	71	9528750.	
47	VIRGINIA	[illegible]	[illegible]	33.57	183	200	77845088.	
48	WASHINGTON	288002.	128770.	44.71	59	68	44603184.	
49	WEST VIRGINIA	[illegible]	67559.	47.61	284	310	26929984.	
50	WISCONSIN	115282.	[illegible]	30.32	65	79	39538384.	
51	WYOMING	42781.	27605.	64.56	31	34	2412750.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	0.	0.0	0	3	0.	
54	GUAM	[illegible]	1113.	4.37	[illegible]	6	1006750.	
55	PUERTO RICO	250043.	89069.	35.62	25	36	32096192.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	9152.	54.45	2	4	2208750.	
TOTAL		27927936.	17416800.	62.36	5417	6316	2901912320.	

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Table 18.

REMOVAL IN ORDER OF INCREASING CAPITAL NEED , $ 4000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	127040.	55.78	110	135	33695824.	
2	ALASKA	28312.	8042.	28.41	51	60	16134000.	
3	ARIZONA	265503.	50710.	19.10	65	71	16778992.	
4	ARKANSAS	79768.	51848.	65.00	107	115	24204672.	
5	CALIFORNIA	1574631.	1242365.	78.90	337	353	518088704.	
6	COLORADO	178838.	150064.	83.91	109	117	33902944.	
7	CONNECTICUT	46616.	28369.	60.86	24	33	44525200.	
8	DELAWARE	23991.	22927.	95.57	15	16	20258992.	
9	DISTRICT OF COLUMBIA	191253.	0.	0.0	0	1	0.	
10	FLORIDA	966318.	488721.	50.55	94	110	176503952.	
11	GEORGIA	462847.	212661.	45.95	189	210	85504208.	
12	HAWAII	11314250.	11240150.	99.35	20	30	45362208.	
13	IDAHO	80406.	9949.	12.37	31	34	8154000.	
14	ILLINOIS	380857.	311774.	81.86	350	359	230327648.	
15	INDIANA	264084.	110441.	41.82	133	148	60061280.	
16	IOWA	312507.	183751.	58.80	253	261	45834656.	
17	KANSAS	119565.	65950.	55.16	115	126	36477680.	
18	KENTUCKY	249093.	186899.	75.03	64	76	63053904.	
19	LOUISIANA	240594.	169135.	70.30	116	130	27835440.	
20	MAINE	105497.	55259.	52.38	75	88	28561424.	
21	MARYLAND	1055872.	93771.	8.88	35	40	64454192.	
22	MASSACHUSETTS	299003.	67956.	22.73	28	38	78824208.	
23	MICHIGAN	281319.	217169.	77.20	105	109	152723792.	
24	MINNESOTA	115466.	90889.	78.71	113	115	53347392.	
25	MISSISSIPPI	113395.	61650.	54.37	65	73	23766000.	
26	MISSOURI	208012.	104531.	50.25	145	151	82376080.	
27	MONTANA	10176.	8982.	88.26	27	30	5465250.	
28	NEBRASKA	321002.	49247.	15.34	111	115	14585250.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225536.	50496.	22.39	60	79	35710448.	
31	NEW JERSEY	885222.	263316.	29.75	102	123	290357248.	
32	NEW MEXICO	78303.	22725.	29.02	15	23	6381750.	
33	NEW YORK	1090653.	329769.	30.24	255	273	463332864.	
34	NORTH CAROLINA	634213.	229777.	36.23	97	122	81100976.	
35	NORTH DAKOTA	33700.	24907.	73.91	51	54	2834250.	
36	OHIO	851287.	300235.	35.27	270	295	203908912.	
37	OKLAHOMA	330071.	126947.	38.46	165	181	53642656.	
38	OREGON	68922.	68922.	100.00	6	6	22175248.	
39	PENNSYLVANIA	634803.	339335.	53.46	375	430	172534752.	
40	RHODE ISLAND	136510.	11462.	8.40	10	17	15280500.	
41	SOUTH CAROLINA	479940.	173976.	36.25	215	249	62483472.	
42	SOUTH DAKOTA	41388.	39230.	94.79	51	53	3913500.	
43	TENNESSEE	510101.	77574.	15.21	58	70	48797152.	
44	TEXAS	620519.	481977.	77.67	285	294	72675824.	
45	UTAH	113026.	27633.	24.45	52	72	18553488.	
46	VERMONT	29278.	9087.	31.04	41	71	12265500.	
47	VIRGINIA	622437.	229723.	36.91	187	200	104413056.	
48	WASHINGTON	288002.	149717.	51.98	62	68	57882672.	
49	WEST VIRGINIA	183908.	110040.	59.83	300	310	35335856.	
50	WISCONSIN	185282.	63913.	34.49	69	79	51015616.	
51	WYOMING	42762.	29533.	69.06	32	34	3296250.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	982.	18.97	1	3	750000.	
54	GUAM	25454.	2433.	9.56	3	6	1908750.	
55	PUERTO RICO	250043.	121658.	48.65	28	36	43548688.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	9152.	54.45	2	4	2208750.	
TOTAL		27927936.	18711472.	67.00	5697	6316	3860246016.	

Table 19.

REMOVAL IN ORDER OF INCREASING CAPITAL NEED , 1 5959996921. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL LOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	164376.	72.18	124	135	50481504.	
2	ALASKA	28312.	11182.	39.50	55	60	25306720.	
3	ARIZONA	265509.	52294.	19.70	67	71	21082464.	
4	ARKANSAS	79768.	79768.	100.00	115	115	36469632.	
5	CALIFORNIA	1574681.	1450015.	92.08	345	353	754156704.	
6	COLORADO	178838.	154904.	86.62	112	117	46602928.	
7	CONNECTICUT	46616.	34024.	72.99	28	33	65521184.	
8	DELAWARE	23491.	22427.	95.57	15	16	20256992.	
9	DISTRICT OF COLUMBIA	191253.	0.	0.0	0	1	0.	
10	FLORIDA	966818.	585028.	60.51	102	110	252409888.	
11	GEORGIA	462847.	322475.	69.67	201	210	127446624.	
12	HAWAII	11314250.	11256621.	99.49	24	30	69203920.	
13	IDAHO	80404.	27846.	34.63	32	34	10208250.	
14	ILLINOIS	380657.	372514.	97.81	355	359	329443584.	
15	INDIANA	264094.	152991.	57.93	139	148	84548768.	
16	IOWA	312509.	225473.	72.15	257	261	70112128.	
17	KANSAS	119565.	93929.	78.56	123	126	53862144.	
18	KENTUCKY	249093.	206161.	82.77	70	76	92728368.	
19	LOUISIANA	240594.	211537.	87.92	127	130	40565104.	
20	MAINE	105489.	65514.	62.10	81	88	40918400.	
21	MARYLAND	1055872.	614958.	58.24	37	40	92807536.	
22	MASSACHUSETTS	299003.	105211.	35.19	33	38	123074192.	
23	MICHIGAN	281219.	278417.	98.97	108	109	229186272.	
24	MINNESOTA	115466.	113090.	97.94	114	115	86422384.	
25	MISSISSIPPI	113394.	76991.	67.90	68	73	33710992.	
26	MISSOURI	208012.	152241.	73.19	148	151	128872320.	
27	MONTANA	10176.	9893.	97.21	29	30	9045750.	
28	NEBRASKA	321002.	65320.	20.35	113	115	22388976.	
29	NEVADA	22427.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	173506.	67170.	38.70	68	79	54672624.	
31	NEW JERSEY	884222.	365758.	41.32	113	123	434800640.	
32	NEW MEXICO	78293.	36086.	46.09	18	23	9777000.	
33	NEW YORK	1090653.	852114.	78.13	265	273	685586944.	
34	NORTH CAROLINA	634211.	386700.	60.99	109	122	121533408.	
35	NORTH DAKOTA	33700.	33700.	100.00	54	54	4634250.	
36	OHIO	851287.	420229.	49.38	286	295	302721280.	
37	OKLAHOMA	330071.	204152.	61.89	176	181	80358352.	
38	OREGON	61922.	61922.	100.00	6	6	22175248.	
39	PENNSYLVANIA	634803.	415114.	65.39	404	430	259401104.	
40	RHODE ISLAND	136516.	19702.	14.43	12	17	22946992.	
41	SOUTH CAROLINA	479540.	255246.	53.18	230	249	93357136.	
42	SOUTH DAKOTA	41388.	39230.	94.79	51	53	3915500.	
43	TENNESSEE	510101.	222279.	43.58	64	70	74275360.	
44	TEXAS	620519.	546209.	88.02	291	294	447568800.	
45	UTAH	111028.	33193.	29.82	58	72	27527184.	
46	VERMONT	29271.	11921.	40.72	51	71	19511232.	
47	VIRGINIA	622435.	381613.	61.28	191	200	156610032.	
48	WASHINGTON	288002.	215856.	74.89	65	68	76781904.	
49	WEST VIRGINIA	183908.	175126.	95.23	308	310	50740064.	
50	WISCONSIN	185262.	116127.	62.68	74	79	74920592.	
51	WYOMING	42762.	29533.	69.06	32	34	3296250.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	982.	18.97	1	3	750000.	
54	GUAM	25494.	2435.	9.56	3	6	1908750.	
55	PUERTO RICO	250043.	171055.	68.40	31	36	62823680.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	9152.	54.45	2	4	2208750.	
TOTAL		27927936.	22012832.	78.82	6003	6316	5675237376.	

Table 20.

REMOVAL IN ORDER OF INCREASING CAPITAL NEED , $ 8000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	202829.	89.06	131	135	68274464.	
2	ALASKA	28312.	13721.	48.46	58	60	33671200.	
3	ARIZONA	265509.	65262.	24.58	68	71	30397456.	
4	ARKANSAS	79768.	79768.	100.00	115	115	36969632.	
5	CALIFORNIA	1574681.	1551307.	98.52	349	353	1022730496.	
6	COLORADO	178838.	157989.	88.34	114	117	61551664.	
7	CONNECTICUT	46616.	38256.	82.07	30	33	84835408.	
8	DELAWARE	23991.	22927.	95.57	15	16	20258992.	
9	DISTRICT OF COLUMBIA	191253.	0.	0.0	0	1	0.	
10	FLORIDA	966818.	655280.	67.78	106	110	324204544.	
11	GEORGIA	462847.	444776.	96.10	206	210	169864848.	
12	HAWAII	11314250.	11272694.	99.63	27	30	95669888.	
13	IDAHO	80404.	73883.	91.89	33	34	13058250.	
14	ILLINOIS	380857.	373398.	98.04	357	359	426763264.	
15	INDIANA	264074.	200325.	75.85	143	148	115219984.	
16	IOWA	312509.	252308.	80.74	259	261	90856368.	
17	KANSAS	119565.	106956.	89.45	125	126	64982128.	
18	KENTUCKY	249093.	219481.	88.11	73	76	117701840.	
19	LOUISIANA	240594.	240596.	100.00	130	130	46904080.	
20	MAINE	105489.	80603.	76.41	85	88	56231136.	
21	MARYLAND	1055872.	901534.	85.38	38	40	127509680.	
22	MASSACHUSETTS	299003.	142098.	47.52	35	38	154199184.	
23	MICHIGAN	281319.	281320.	100.00	109	109	317386240.	
24	MINNESOTA	115465.	113090.	97.94	114	115	86422384.	
25	MISSISSIPPI	113374.	89000.	78.49	70	73	43910992.	
26	MISSOURI	208012.	153659.	73.87	149	151	164872320.	
27	MONTANA	10176.	9893.	97.21	29	30	9045750.	
28	NEBRASKA	321002.	65320.	20.35	113	115	22388976.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225506.	101096.	44.83	72	79	69695120.	
31	NEW JERSEY	885222.	394122.	44.52	118	123	555346688.	
32	NEW MEXICO	78293.	56787.	72.53	21	23	14355750.	
33	NEW YORK	1090653.	958780.	87.91	270	273	885140992.	
34	NORTH CAROLINA	634218.	472590.	74.52	117	122	165834352.	
35	NORTH DAKOTA	33700.	33700.	100.00	54	54	4634250.	
36	OHIO	851287.	663674.	77.96	292	295	401264128.	
37	OKLAHOMA	330071.	311078.	94.25	180	181	102613072.	
38	OREGON	68922.	68922.	100.00	6	6	22175248.	
39	PENNSYLVANIA	650303.	531750.	81.77	420	430	343935232.	
40	RHODE ISLAND	136510.	44805.	32.82	14	17	36003240.	
41	SOUTH CAROLINA	479960.	414927.	86.45	239	249	123484576.	
42	SOUTH DAKOTA	41389.	39230.	94.79	51	53	3913500.	
43	TENNESSEE	510191.	330909.	64.87	67	70	97999344.	
44	TEXAS	620519.	620260.	99.96	293	294	126989280.	
45	UTAH	118026.	53838.	45.62	63	72	37498400.	
46	VERMONT	29278.	14113.	48.21	59	71	25580208.	
47	VIRGINIA	622439.	432932.	69.55	194	200	207428512.	
48	WASHINGTON	288002.	220199.	76.46	66	68	97444400.	
49	WEST VIRGINIA	183908.	183912.	100.00	310	310	65201552.	
50	WISCONSIN	185282.	129959.	70.14	76	79	100345328.	
51	WYOMING	42762.	33173.	77.58	33	34	5264250.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	982.	18.97	1	3	750000.	
54	GUAM	25454.	3025.	11.89	4	6	3377250.	
55	PUERTO RICO	250043.	180038.	72.00	33	36	81348656.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	15703.	93.43	3	4	5430000.	
TOTAL		27927936.	24124176.	86.38	6154	6316	7392022528.	

Table 21.

REMOVAL IN ORDER OF INCREASING CAPITAL NEED . . . 1999997440. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL [illegible]	[illegible] REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227742.	220101.	96.95	133	135	75317456.	
2	ALASKA	28212.	13721.	48.46	58	60	33671200.	
3	ARIZONA	266206.	65262.	24.58	68	71	30397456.	
4	ARKANSAS	79768.	79768.	100.00	115	115	26965632.	
5	CALIFORNIA	1574081.	1572173.	99.87	350	353	1134180352.	
6	COLORADO	178618.	166129.	93.01	115	117	69427456.	
7	CONNECTICUT	46616.	38757.	83.14	31	33	103941648.	
8	DELAWARE	23991.	22927.	95.57	15	16	20256992.	
9	DISTRICT OF COLUMBIA	161253.	0.	0.0	0	1	0.	
10	FLORIDA	966818.	656197.	67.87	107	110	361704448.	
11	GEORGIA	462847.	445568.	96.27	207	210	181531068.	
12	HAWAII	11314250.	11284043.	99.73	28	30	108719888.	
13	IDAHO	80404.	73883.	91.89	33	34	13058250.	
14	ILLINOIS	380657.	380309.	99.91	358	359	522304768.	
15	INDIANA	264094.	258323.	97.81	144	148	127219984.	
16	IOWA	312805.	252308.	80.74	259	261	90656368.	
17	KANSAS	119565.	119566.	100.00	126	126	77657120.	
18	KENTUCKY	249093.	228672.	91.80	74	76	135826832.	
19	LOUISIANA	240594.	240596.	100.00	130	130	46604080.	
20	MAINE	105480.	82438.	78.15	86	88	62981136.	
21	MARYLAND	1055872.	901534.	85.38	38	40	127509600.	
22	MASSACHUSETTS	299003.	146465.	48.98	36	38	177074176.	
23	MICHIGAN	281319.	281320.	100.00	109	109	317386240.	
24	MINNESOTA	115466.	113090.	97.94	114	115	86422384.	
25	MISSISSIPPI	113394.	96506.	85.11	71	73	50735984.	
26	MISSOURI	208012.	153669.	73.87	149	151	164872320.	
27	MONTANA	10176.	9893.	97.21	29	30	9045750.	
28	NEBRASKA	321002.	65320.	20.35	113	115	22388976.	
29	NEVADA	28426.	18257.	64.39	19	20	49410736.	
30	NEW HAMPSHIRE	225506.	108744.	48.22	74	79	62703856.	
31	NEW JERSEY	885222.	427399.	48.28	120	123	645871616.	
32	NEW MEXICO	78063.	67644.	86.65	22	23	16478250.	
33	NEW YORK	1090653.	1090522.	99.99	272	273	1006278784.	
34	NORTH CAROLINA	634218.	578259.	91.18	120	122	187603072.	
35	NORTH DAKOTA	33700.	33700.	100.00	54	54	4434250.	
36	OHIO	775287.	715103.	92.24	293	295	429164032.	
37	OKLAHOMA	330071.	330075.	100.00	181	181	116165568.	
38	OREGON	68822.	68822.	100.00	6	6	22175248.	
39	PENNSYLVANIA	634803.	562187.	88.56	425	430	301334272.	
40	RHODE ISLAND	135910.	44605.	32.82	14	17	36000240.	
41	SOUTH CAROLINA	479940.	436602.	90.97	242	249	137793108.	
42	SOUTH DAKOTA	41318.	41337.	99.66	52	53	41636500.	
43	TENNESSEE	510101.	363109.	71.18	68	70	114784032.	
44	TEXAS	620519.	620520.	100.00	294	294	146443760.	
45	UTAH	116466.	63065.	54.15	65	72	42645888.	
46	VERMONT	28056.	16166.	57.62	60	71	28095696.	
47	VIRGINIA	622439.	448820.	72.11	195	200	230003504.	
48	WASHINGTON	288007.	254644.	88.47	67	68	173169392.	
49	WEST VIRGINIA	183908.	183912.	100.00	310	310	65201552.	
50	WISCONSIN	185282.	151456.	81.74	77	79	117895328.	
51	WYOMING	42762.	42762.	100.00	34	34	7514250.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	3477.	67.20	2	3	1672500.	
54	GUAM	25454.	3025.	11.89	4	6	3377250.	
55	PUERTO RICO	250043.	186276.	74.50	34	36	94604896.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	15703.	93.43	3	4	5430000.	
TOTAL		27927936.	24915232.	89.21	6203	6316	8297119744.	

TABLES 22 THROUGH 27

State BOD removals and sources controlled for cumulative federal expenditures of $2, $4, $6, $8, $9 billion under the priority of construction in order of increasing pounds of BOD removed per dollar

Table 22.

REMOVAL IN ORDER OF DECREASING BOD/DOLLAR $ 2000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227763.	141783.	62.26	38	135	17238720.	
2	ALASKA	28317.	8501.	30.02	9	60	8442000.	
3	ARIZONA	265567.	12694.	4.78	12	71	750750.	
4	ARKANSAS	79768.	63539.	79.65	32	115	12459750.	
5	CALIFORNIA	1574631.	1219540.	77.45	133	353	250692864.	
6	COLORADO	178838.	139000.	77.72	72	117	17163984.	
7	CONNECTICUT	46616.	25400.	54.49	12	33	19508992.	
8	DELAWARE	23991.	17079.	71.19	11	16	7170750.	
9	DISTRICT OF COLUMBIA	191253.	0.	0.0	0	1	0.	
10	FLORIDA	965318.	345072.	35.69	20	110	38362416.	
11	GEORGIA	462847.	269748.	58.28	72	210	35573168.	
12	HAWAII	11314250.	11242418.	99.37	7	30	19994992.	
13	IDAHO	80404.	46037.	57.26	1	34	2850000.	
14	ILLINOIS	380857.	293726.	77.12	240	359	118815264.	
15	INDIANA	264094.	156998.	59.45	62	148	29160544.	
16	IOWA	312509.	175428.	56.14	131	261	19310912.	
17	KANSAS	119565.	66449.	55.58	39	126	17539472.	
18	KENTUCKY	249093.	183529.	73.68	21	76	31229200.	
19	LOUISIANA	240594.	162640.	67.60	35	130	13097250.	
20	MAINE	105497.	39804.	37.73	39	88	9896250.	
21	MARYLAND	1055872.	522120.	49.45	2	40	19312496.	
22	MASSACHUSETTS	299003.	84452.	28.24	7	38	35205728.	
23	MICHIGAN	281319.	174582.	62.06	51	109	64136864.	
24	MINNESOTA	115466.	80227.	69.48	78	115	29878208.	
25	MISSISSIPPI	113374.	58655.	51.73	37	73	12222750.	
26	MISSOURI	208012.	110598.	53.17	86	151	28684112.	
27	MONTANA	10176.	8202.	80.60	21	30	2878500.	
28	NEBRASKA	321002.	21055.	6.56	21	115	707250.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225506.	36271.	16.08	4	79	3182250.	
31	NEW JERSEY	885222.	90287.	10.20	23	123	19382224.	
32	NEW MEXICO	78293.	11939.	15.25	2	23	1647750.	
33	NEW YORK	1090653.	768488.	70.46	97	273	222306160.	
34	NORTH CAROLINA	634218.	360820.	56.89	21	122	41387888.	
35	NORTH DAKOTA	33700.	23509.	69.76	28	54	1509000.	
36	OHIO	851287.	437426.	51.38	48	295	101288832.	
37	OKLAHOMA	330071.	165106.	50.02	15	181	26205696.	
38	OREGON	68922.	52342.	75.94	1	6	10950000.	
39	PENNSYLVANIA	634803.	340332.	53.61	120	430	80106304.	
40	RHODE ISLAND	136510.	76737.	56.25	3	17	8272500.	
41	SOUTH CAROLINA	479940.	288395.	60.09	55	249	28064912.	
42	SOUTH DAKOTA	41333.	33039.	79.83	21	53	2049000.	
43	TENNESSEE	510101.	232555.	45.59	14	70	22315456.	
44	TEXAS	620519.	455639.	73.43	123	294	32095232.	
45	UTAH	135326.	46941.	34.69	7	72	9273750.	
46	VERMONT	29273.	8849.	30.23	16	71	6056250.	
47	VIRGINIA	622439.	242979.	39.04	77	200	45874912.	
48	WASHINGTON	288002.	149555.	51.93	22	68	25409200.	
49	WEST VIRGINIA	183908.	112471.	61.16	90	310	17919680.	
50	WISCONSIN	185282.	77194.	41.66	20	79	21378704.	
51	WYOMING	42762.	25258.	59.07	14	34	1453500.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	0.	0.0	0	3	0.	
54	GUAM	25454.	0.	0.0	0	6	0.	
55	PUERTO RICO	250043.	122244.	48.89	6	35	16192500.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	8773.	52.20	1	4	1751250.	
TOTAL		27927936.	19835984.	71.03	2135	6316	1611505920.	

Table 23.

REMOVAL IN ORDER OF DECREASING BOD/DOLLAR , 1 3000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	163408.	71.75	53	135	25451120.	
2	ALASKA	28812.	8651.	30.02	9	60	8442000.	
3	ARIZONA	264728.	12654.	4.78	12	71	750750.	
4	ARKANSAS	79768.	73888.	92.63	78	115	18658176.	
5	CALIFORNIA	1574681.	1411763.	89.65	191	353	300316680.	
6	COLORADO	178858.	139856.	78.20	76	117	17746448.	
7	CONNECTICUT	46616.	31517.	67.61	14	33	34604480.	
8	DELAWARE	23991.	17079.	71.19	11	16	7170750.	
9	DISTRICT OF COLUMBIA	191253.	0.	0.0	0	1	0.	
10	FLORIDA	966816.	624281.	64.57	38	110	131210816.	
11	GEORGIA	462847.	365664.	79.00	97	210	64690512.	
12	HAWAII	11314270.	11253203.	99.46	9	30	30924720.	
13	IDAHO	80404.	66325.	82.49	15	34	5530500.	
14	ILLINOIS	380857.	339776.	89.21	285	359	175475472.	
15	INDIANA	264094.	190751.	72.23	77	148	44107952.	
16	IOWA	312509.	175428.	56.14	131	261	19310912.	
17	KANSAS	119565.	85840.	71.79	55	126	27300640.	
18	KENTUCKY	249093.	195979.	78.68	28	76	43893664.	
19	LOUISIANA	240594.	190669.	79.25	52	130	20083440.	
20	MAINE	105489.	62334.	59.09	45	88	21555728.	
21	MARYLAND	1055872.	522120.	49.45	2	40	19312496.	
22	MASSACHUSETTS	299003.	84452.	28.24	7	38	35205728.	
23	MICHIGAN	281319.	227650.	80.92	63	109	110429806.	
24	MINNESOTA	115466.	85026.	73.64	89	115	36431648.	
25	MISSISSIPPI	113394.	64260.	56.70	45	73	16573500.	
26	MISSOURI	208012.	110598.	53.17	66	151	26684112.	
27	MONTANA	10176.	9103.	89.45	22	30	4290000.	
28	NEBRASKA	321002.	21055.	6.56	21	115	707250.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225506.	150794.	66.87	16	79	26996880.	
31	NEW JERSEY	885222.	584804.	66.06	39	123	216493376.	
32	NEW MEXICO	78253.	25604.	32.70	4	23	4502750.	
33	NEW YORK	1090653.	880852.	80.76	128	273	337473536.	
34	NORTH CAROLINA	634218.	401040.	63.23	24	122	52206624.	
35	NORTH DAKOTA	33700.	26645.	79.07	29	54	2109000.	
36	OHIO	851287.	557395.	65.48	81	295	144976864.	
37	OKLAHOMA	330071.	208247.	63.09	29	161	37980624.	
38	OREGON	68922.	68922.	100.00	6	6	22175232.	
39	PENNSYLVANIA	634803.	449413.	70.80	199	430	129858656.	
40	RHODE ISLAND	136510.	76787.	56.25	3	17	8272500.	
41	SOUTH CAROLINA	479540.	332084.	69.19	67	249	43067856.	
42	SOUTH DAKOTA	41388.	38168.	92.22	30	53	3173250.	
43	TENNESSEE	510101.	261179.	51.20	16	70	30850448.	
44	TEXAS	620519.	535231.	86.26	159	294	54729968.	
45	UTAH	118026.	46456.	39.36	9	72	11092500.	
46	VERMONT	29278.	10612.	36.25	18	71	7771500.	
47	VIRGINIA	622439.	300359.	48.26	78	200	71604400.	
48	WASHINGTON	288002.	190848.	66.27	38	68	47596864.	
49	WEST VIRGINIA	170508.	128023.	75.05	176	310	26949056.	
50	WISCONSIN	185282.	110159.	59.46	22	79	40439952.	
51	WYOMING	42762.	25258.	59.07	14	34	1453500.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	0.	0.0	0	3	0.	
54	GUAM	25454.	0.	0.0	0	6	0.	
55	PUERTO RICO	250043.	177755.	71.09	7	36	31192496.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	8773.	52.20	1	4	1751250.	
TOTAL		27927936.	22146400.	79.30	2822	6316	2686450048.	

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Table 24.

REMOVAL IN ORDER OF DECREASING BOD/DOLLAR , $ 4000000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	181195.	79.56	66	135	33620800.	
2	ALASKA	28312.	8501.	30.02	9	60	8442000.	
3	ARIZONA	265507.	12694.	4.78	12	71	750750.	
4	ARKANSAS	79764.	77705.	97.41	94	115	24545872.	
5	CALIFORNIA	1574681.	1502391.	95.41	255	353	520893696.	
6	COLORADO	178833.	152710.	85.39	81	117	27200896.	
7	CONNECTICUT	46616.	32977.	70.74	15	33	40054480.	
8	DELAWARE	23991.	22927.	95.57	15	16	20258960.	
9	DISTRICT OF COLUMBIA	191253.	0.	0.0	0	1	0.	
10	FLORIDA	965918.	629452.	65.11	39	110	133460816.	
11	GEORGIA	462847.	406293.	87.78	116	210	85875376.	
12	HAWAII	11314250.	11265614.	99.57	12	30	45380192.	
13	IDAHO	80404.	70288.	87.42	20	34	8145750.	
14	ILLINOIS	380857.	367447.	96.48	328	359	239430464.	
15	INDIANA	264094.	209717.	79.41	88	148	54635632.	
16	IOWA	312509.	241362.	77.23	156	261	39092000.	
17	KANSAS	119565.	97723.	81.73	87	126	36124944.	
18	KENTUCKY	249093.	206939.	83.08	42	76	59141088.	
19	LOUISIANA	240594.	212913.	88.49	73	130	27766320.	
20	MAINE	105489.	71271.	67.56	53	88	27414656.	
21	MARYLAND	1055872.	844959.	80.02	8	40	62492944.	
22	MASSACHUSETTS	299033.	84452.	28.24	7	38	35205728.	
23	MICHIGAN	281319.	263994.	93.84	77	109	161935232.	
24	MINNESOTA	115466.	85026.	73.64	89	115	36431648.	
25	MISSISSIPPI	113394.	80020.	70.57	47	73	24823488.	
26	MISSOURI	208012.	174445.	83.86	106	151	84801216.	
27	MONTANA	10176.	9833.	96.63	27	30	6051750.	
28	NEBRASKA	321002.	21055.	6.56	21	115	707250.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225505.	170146.	75.45	26	79	37306336.	
31	NEW JERSEY	885222.	660179.	74.58	58	123	286741504.	
32	NEW MEXICO	78293.	33033.	42.19	5	23	5829000.	
33	NEW YORK	1090653.	960592.	88.07	167	273	463066880.	
34	NORTH CAROLINA	634218.	489202.	77.13	33	122	81118336.	
35	NORTH DAKOTA	33700.	32428.	96.23	34	54	3338250.	
36	OHIO	851237.	663784.	77.97	131	295	202285520.	
37	OKLAHOMA	330071.	253549.	76.82	48	181	53480736.	
38	OREGON	64922.	64922.	100.00	6	6	22175232.	
39	PENNSYLVANIA	634803.	506545.	79.80	266	430	171207968.	
40	RHODE ISLAND	136510.	97160.	71.17	4	17	15573750.	
41	SOUTH CAROLINA	479940.	379307.	79.03	93	249	62608144.	
42	SOUTH DAKOTA	41388.	39213.	94.74	48	53	3853500.	
43	TENNESSEE	510101.	261179.	51.20	16	70	30350448.	
44	TEXAS	620513.	572650.	92.29	194	294	72854992.	
45	UTAH	118026.	65324.	55.35	15	72	18707232.	
46	VERMONT	29278.	14534.	49.64	19	71	11631000.	
47	VIRGINIA	622437.	379311.	60.94	89	200	108205072.	
48	WASHINGTON	288002.	196507.	68.23	40	68	46644608.	
49	WEST VIRGINIA	183908.	156476.	85.08	275	310	35068688.	
50	WISCONSIN	185282.	115598.	62.39	30	79	44360912.	
51	WYOMING	42762.	25258.	59.07	14	34	1453500.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	0.	0.0	0	3	0.	
54	GUAM	25456.	0.	0.0	0	6	0.	
55	PUERTO RICO	250041.	203851.	81.53	10	36	43342480.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	8773.	52.20	1	4	1751250.	
TOTAL		27927936.	23692800.	84.84	3583	6316	3671270400.	

Table 25.

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REMOVAL IN ORDER OF DECREASING BOD/DOLLAR   , 1    5999996928. AVAILABLE,  75.00% CAPITAL,   0.0 % O & M
        STATE                     TOTAL BOD   BOD REMOVED      % REMOVED  # REMOVED # TOTAL       CAPITAL         O&M
  1   ALABAMA                      227743.      204198.          89.66        94      135        48465376.
  2   ALASKA                        28312.        8501.          30.02         5       60         8442000.
  3   ARIZONA                      265509.      237333.          89.39        34       71        25279872.
  4   ARKANSAS                      79768.       79767.         100.00       115      115        36564520.
  5   CALIFORNIA                  1574681.     1565984.          99.45       333      353       789573184.
  6   COLORADO                     178838.      172667.          96.55       100      117        49764528.
  7   CONNECTICUT                   46616.       39909.          85.61        22       33        64457704.
  8   DELAWARE                      23991.       22927.          95.57        15       16        20255960.
  9   DISTRICT OF COLUMBIA         191253.           0.           0.0          0        1               0.
 10   FLORIDA                      966818.      872370.          90.23        72      110       264540368.
 11   GEORGIA                      462847.      435807.          94.16       161      210       119577752.
 12   HAWAII                     11314256.    11265614.          99.57        12       30        45480192.
 13   IDAHO                         80404.       72463.          90.12        22       34        10110750.
 14   ILLINOIS                     380857.      377907.          99.23       350      359       360211200.
 15   INDIANA                      264094.      252145.          95.48       124      148        40551424.
 16   IOWA                         312309.      303596.          97.15       238      261        69655176.
 17   KANSAS                       119565.      114873.          96.03       107      126        54990320.
 18   KENTUCKY                     249093.      218863.          87.87        47       76        62007072.
 19   LOUISIANA                    240594.      238373.          99.08       115      130        41653576.
 20   MAINE                        105419.       88823.          84.01        66       68        43111360.
 21   MARYLAND                    1055872.      867856.          82.19        12       40        71592072.
 22   MASSACHUSETTS                299003.      222216.          74.32        14       38       123636688.
 23   MICHIGAN                     281319.      278321.          98.93       106      109       222756386.
 24   MINNESOTA                    115466.      113047.          97.90       113      115        84843968.
 25   MISSISSIPPI                  113394.       89515.          79.29        56       73        31651544.
 26   MISSOURI                     208012.      195400.          93.94       130      151       172237568.
 27   MONTANA                       10176.        9882.          97.11        28       30         6376750.
 28   NEBRASKA                     321002.       21055.           6.56        21      115          767250.
 29   NEVADA                        22426.        5663.          25.25        18       20         3135750.
 30   NEW HAMPSHIRE                225506.      191307.          84.83        39       79        56277504.
 31   NEW JERSEY                   885222.      764347.          86.35        67      123       425766976.
 32   NEW MEXICO                    78293.       55299.          70.63         9       23        11011500.
 33   NEW YORK                    1090653.     1051476.          96.40       218      273       673665792.
 34   NORTH CAROLINA               634218.      567474.          89.48        61      122       124879136.
 35   NORTH DAKOTA                  33700.       33700.         100.00        54       54         4634250.
 36   OHIO                         851287.      740924.          87.04       197      295       273621120.
 37   OKLAHOMA                     330071.      287343.          87.05       104      181        71655552.
 38   OREGON                        68922.       68922.         100.00         6        6         2217232.
 39   PENNSYLVANIA                 634803.      568395.          89.54       364      430       257497776.
 40   RHODE ISLAND                 136510.      105279.          77.12         6       17        20369984.
 41   SOUTH CAROLINA               479940.      422349.          88.00       140      249        67021840.
 42   SOUTH DAKOTA                  41388.       39213.          94.74        48       53         3853500.
 43   TENNESSEE                    510101.      365036.          71.56        20       70        63255440.
 44   TEXAS                        620519.      618362.          99.65       262      294       109387792.
 45   UTAH                         118026.       80905.          68.55        28       72        27152656.
 46   VERMONT                       29276.       21097.          72.06        27       71        16804480.
 47   VIRGINIA                     622439.      450376.          72.36       134      200       151557328.
 48   WASHINGTON                   288002.      242019.          84.03        55       68        83481552.
 49   WEST VIRGINIA                183908.      179113.          97.39       301      310        53526768.
 50   WISCONSIN                    185282.      157358.          84.93        39       79        79957840.
 51   WYOMING                       42762.       36836.          86.14        24       34         4320000.
 52   WAKE ISLAND                       0.           0.           0.0          0        0               0.
 53   AMERICAN SAMOA                 5175.        2496.          48.23         1        3          422800.
 54   GUAM                          25454.       13475.          52.94         1        6         2025000.
 55   PUERTO RICO                  250043.      228195.          91.26        15       36        65030192.
 56   TRUST TERRITORIES                 0.           0.           0.0          0        0               0.
 57   VIRGIN ISLANDS                16806.       15324.          91.18         2        4          497500.
TOTAL                            27927937.    25681440.          91.96      4762     6316      5611737592.
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Table 26.

REMOVAL IN ORDER OF DECREASING BOD/DOLLAR , $ 800000000. AVAILABLE, 75.00% CAPITAL, 0.0 % O & M

	STATE	TOTAL BOD	BOD REMOVED	% REMOVED	# REMOVED	# TOTAL	CAPITAL	O&M
1	ALABAMA	227743.	221250.	97.15	115	135	68814240.	
2	ALASKA	28312.	24006.	84.79	20	60	32501168.	
3	ARIZONA	265507.	246446.	92.82	43	71	29866304.	
4	ARKANSAS	79768.	79767.	100.00	115	115	36969520.	
5	CALIFORNIA	1574681.	1571937.	99.83	348	353	1027144192.	
6	COLORADO	178833.	177515.	99.26	113	117	66553184.	
7	CONNECTICUT	46616.	42645.	91.48	26	33	91733168.	
8	DELAWARE	23991.	22927.	95.57	15	16	20258960.	
9	DISTRICT OF COLUMBIA	171253.	0.	0.0	0	1	0.	
10	FLORIDA	966318.	942975.	97.53	91	110	347591936.	
11	GEORGIA	462847.	460280.	99.45	192	210	172032576.	
12	HAWAII	11314250.	11299330.	99.87	16	30	92149424.	
13	IDAHO	80404.	72463.	90.12	22	34	10110750.	
14	ILLINOIS	380857.	380197.	99.83	356	359	456734720.	
15	INDIANA	264094.	261153.	98.89	136	148	120253616.	
16	IOWA	312509.	311897.	99.80	255	261	88184784.	
17	KANSAS	119565.	119338.	99.81	124	126	73681728.	
18	KENTUCKY	249093.	237203.	95.23	55	76	124860512.	
19	LOUISIANA	240594.	240594.	100.00	130	130	46903648.	
20	MAINE	105437.	95351.	90.39	75	88	53997568.	
21	MARYLAND	1055872.	867856.	82.19	12	40	71892672.	
22	MASSACHUSETTS	299003.	239803.	80.20	17	38	144636688.	
23	MICHIGAN	281319.	281318.	100.00	109	109	317385728.	
24	MINNESOTA	115466.	113047.	97.90	113	115	84843968.	
25	MISSISSIPPI	113394.	105361.	92.92	66	73	47878416.	
26	MISSOURI	208012.	204762.	98.44	147	151	170255232.	
27	MONTANA	10176.	9882.	97.11	28	30	6876750.	
28	NEBRASKA	321002.	228097.	71.06	25	115	31096464.	
29	NEVADA	22426.	5663.	25.25	18	20	3135750.	
30	NEW HAMPSHIRE	225536.	205166.	90.98	51	79	72771408.	
31	NEW JERSEY	885222.	816579.	92.25	96	123	563755264.	
32	NEW MEXICO	78293.	67518.	86.24	11	23	14671500.	
33	NEW YORK	1090653.	1089775.	99.92	268	273	903191040.	
34	NORTH CAROLINA	634218.	610697.	96.29	79	122	161708528.	
35	NORTH DAKOTA	33700.	33700.	100.00	54	54	4634250.	
36	OHIO	851287.	827597.	97.22	255	295	409584640.	
37	OKLAHOMA	330071.	328268.	99.45	172	181	107685456.	
38	OREGON	63922.	63922.	100.00	6	6	22175232.	
39	PENNSYLVANIA	634803.	597990.	94.20	372	430	346192896.	
40	RHODE ISLAND	136510.	117163.	85.83	7	17	28994976.	
41	SOUTH CAROLINA	479940.	463458.	96.57	202	249	126505872.	
42	SOUTH DAKOTA	41388.	39213.	94.74	48	53	3853500.	
43	TENNESSEE	510101.	430849.	84.46	28	70	88272624.	
44	TEXAS	620519.	620256.	99.96	291	294	126771120.	
45	UTAH	118026.	94857.	80.37	32	72	36230128.	
46	VERMONT	29278.	24903.	85.06	40	71	25423408.	
47	VIRGINIA	622431.	505596.	81.23	149	200	198713968.	
48	WASHINGTON	288002.	247819.	86.05	57	68	91491536.	
49	WEST VIRGINIA	183708.	183707.	100.00	310	310	65200464.	
50	WISCONSIN	185282.	173690.	93.74	56	79	103423232.	
51	WYOMING	42762.	38763.	90.65	25	34	5203500.	
52	WAKE ISLAND	0.	0.	0.0	0	0	0.	
53	AMERICAN SAMOA	5175.	2495.	48.23	1	3	922500.	
54	GUAM	25454.	13475.	52.94	1	6	2925000.	
55	PUERTO RICO	250043.	238887.	95.54	19	36	85807424.	
56	TRUST TERRITORIES	0.	0.	0.0	0	0	0.	
57	VIRGIN ISLANDS	16806.	15703.	93.43	3	4	5430000.	
TOTAL		27927936.	26719984.	95.67	5415	6316	7436824576.	

Table 27.

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REMOVAL IN ORDER OF DECREASING BOD/DOLLAR   , 1     8999997440. AVAILABLE,  75.00% CAPITAL,   0.0 % O & M
        STATE                  TOTAL BOD    BOD REMOVED      % REMOVED  # REMOVED # TOTAL        CAPITAL        O&M
 1   ALABAMA                     227743.       222979.          97.91       121       135        72036192.
 2   ALASKA                       28312.        25321.          89.44        33        60        36611088.
 3   ARIZONA                     265509.       246446.          92.82        43        71        29886304.
 4   ARKANSAS                     79768.        79767.         100.00       115       115        36969520.
 5   CALIFORNIA                 1574681.      1573004.          99.89       349       353      1160167424.
 6   COLORADO                    178638.       177675.          99.46       115       117        72463920.
 7   CONNECTICUT                  46616.        43020.          92.29        27        33        96254160.
 8   DELAWARE                     23991.        22927.          95.57        15        16        20258960.
 9   DISTRICT OF COLUMBIA        151253.            0.           0.0          0         1               0.
10   FLORIDA                     966818.       958899.          99.18       101       110       392399872.
11   GEORGIA                     462847.       461558.          99.72       197       210       183620064.
12   HAWAII                    11314250.     11304312.          99.91        18        30       105184416.
13   IDAHO                        80404.        79151.          98.44        27        34        17825216.
14   ILLINOIS                    380857.       380504.          99.91       358       359       522303232.
15   INDIANA                     264094.       261879.          99.16       142       148       135023328.
16   IOWA                        312509.       312155.          99.89       258       261        94582272.
17   KANSAS                      119565.       119564.         100.00       126       126        77656720.
18   KENTUCKY                    249093.       237203.          95.23        55        76       124860512.
19   LOUISIANA                   240594.       240594.         100.00       130       130        46903648.
20   MAINE                       105488.        95351.          90.39        75        88        53997568.
21   MARYLAND                   1055872.      1002083.          94.91        20        40       143729388.
22   MASSACHUSETTS               299663.       271495.          90.60        18        38       189636688.
23   MICHIGAN                    281319.       281318.         100.00       109       109       317365728.
24   MINNESOTA                   115466.       113047.          97.90       113       115        84843968.
25   MISSISSIPPI                 113394.       109177.          96.28        68        73        55573408.
26   MISSOURI                    208012.       204762.          98.44       147       151       170255232.
27   MONTANA                      10176.         9882.          97.11        28        30         6876750.
28   NEBRASKA                    321002.       242800.          75.64        41       115        33767840.
29   NEVADA                       22426.        15337.          68.39        19        20        49410736.
30   NEW HAMPSHIRE               225508.       210308.          93.26        54        79        81107648.
31   NEW JERSEY                  685222.       639176.          94.60       102       123       658940672.
32   NEW MEXICO                   78293.        71448.          91.26        14        23        16011750.
33   NEW YORK                   1050653.      1050475.          99.98       271       273       996103650.
34   NORTH CAROLINA              634218.       628704.          99.13        97       122       187593120.
35   NORTH DAKOTA                 33700.        33700.         100.00        54        54         4634250.
36   OHIO                        851287.       834323.          98.01       279       295       440264568.
37   OKLAHOMA                    330071.       330071.         100.00       181       181       116164880.
38   OREGON                       68922.        68922.         100.00         6         6        22175232.
39   PENNSYLVANIA                634803.       606518.          95.54       389       430       383108608.
40   RHODE ISLAND                136510.       126733.          92.84         9        17        38879968.
41   SOUTH CAROLINA              479940.       471770.          98.30       222       249       142545984.
42   SOUTH DAKOTA                 41388.        41332.          99.86        52        53         9163500.
43   TENNESSEE                   510101.       479380.          93.98        35        70       115088832.
44   TEXAS                       620519.       620518.         100.00       294       294       148353088.
45   UTAH                        118026.       102046.          86.46        41        72        41217584.
46   VERMONT                      29276.        26127.          89.24        46        71        28520112.
47   VIRGINIA                    622439.       505596.          81.23       149       200       196713968.
48   WASHINGTON                  288002.       247819.          86.05        57        68        91491536.
49   WEST VIRGINIA               183508.       183507.         100.00       310       310        65200464.
50   WISCONSIN                   185282.       180646.          97.50        58        79       120472976.
51   WYOMING                      42762.        42762.         100.00        34        34         7514250.
52   WAKE ISLAND                      0.            0.           0.0          0         0               0.
53   AMERICAN SAMOA                5175.         2496.          48.23         1         3          922500.
54   GUAM                         25454.        13475.          52.94         1         6         2925000.
55   PUERTO RICO                 250043.       238887.          95.54        19        36        85807424.
56   TRUST TERRITORIES                0.            0.           0.0          0         0               0.
57   VIRGIN ISLANDS               16808.        15703.          93.43         3         4         5430000.
TOTAL                          27927930.     27104944.          97.05      5646      6316      8350772736.
```

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APPENDIX E

MUNICIPAL CLASSIFICATION ANALYSIS

RELEVANT CHARACTERISTICS

The objective of the classification scheme is to place communities in the nation into categories representative of different plant design and financing situations and to relate these to environmental, community, and individual impacts. Our working hypothesis was that there are sets of characteristics that affect (1) decisions made by cities regarding choice of process types and project size in treatment plants and (2) the fiscal and distributional impacts resulting from these decisions and the particular financing program in effect.

The plant size decision is affected by existing and projected flow: functions of sewered population, growth rate, industrial load, and existing treatment capacity,* and by administrative cash flow and debt burden. The fiscal impact and the distribution of the cost burden over individuals are a function of existing debt, tax base, local financing mechanisms, and distribution of family income and wealth. On the basis of these considerations and data available, the following list of community characteristics+ was compiled:

a. population;

b. population growth rate;

c. per capita income (or median family income);

d. revenues per capita;

e. debt per capita;

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* For a discussion of the implications of growth on treatment demand and traditional design rules, see Muhich, A. J., "Capacity Expansion of Water Treatment Facilities," Ph.D. Thesis, Harvard University, 1966.

+ See "Definitions of Class Variables" below.

f. percentage of population sewered;

g. value in existing treatment capacity; and

h. industrial hydraulic load as a percentage of total present hydraulic load.

The classification scheme is used to develop profiles of communities as background to estimating environmental and financial impact of municipal decisions made in response to the 1977 and 1983 treatment regulations and to alternative financing programs.

Availability of Data

Sources of data for the above list are as follows:

(1) Population data are taken from the 1970 Population Census. Unfortunately, such data are not as readily available as one would expect; just to retrieve populations of places under 25,000 population requires manipulation of 62 reels of tape (1st count, file B). Populations of places over 25,000 are available from the City and County Data Book* computer tape and populations together with counties are listed in that book for places of over 2,500 inhabitants. There is no readily available source of population data (to say nothing of other data) for places under 2,500 inhabitants. Because of data retrieval costs, classification analyses therefore were performed only for places of over 25,000 population.

(2) Population growth rate data are available from the Census Bureau and the Bureau of Economic Analysis; these include population projections. For the purposes of the classification analysis, 1960-1970 population change data were used from the City and County Data Book computer tape.

(3) Income data are available from four sources:

(a) Regional Accounts Division, Office of Business Economics (OBE);

(b) Internal Revenue Service (IRS);

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* Bureau of the Census, Social and Economic Statistics Administration, U.S. Department of Commerce, "1972 City and County Data Book," May, 1973.

c. Census Bureau; and

d. Sales Management Survey of Buying Power (and other private services such as National Planning Association and Market Guide).

OBE and IRS data are not useful to this study; OBE data are on a where-earned basis; IRS data are on a "selected major metropolitan area" and zip code area basis. Sales Management* income data are updated annually, give "effective buying income" (essentially disposable income) by income class, and are available on tapes. Census Bureau data, however, can be used more conveniently and inexpensively as described below.

The 1970 Census of Population has estimates of 1969 income (wages or salary, net non-farm and farm self-employment, retirement including social security, public assistance, interest and dividends, net rental, and other income excluding receipts from sale of personal property, capital gains, lump-sum insurance or inheritance payments, or payments in kind). These are based on a 20 percent sample for places. Manipulation of the 104 reels of tape (4th count, file C), however, would be expensive and time consuming. The alternative chosen is use of City and County Data Book data for places over 25,000 population.

(4) Revenues per capita data come from the Governments Division of the Census Bureau. Two series are relevant: the quinquennial census of governments and the annual governmental finances review. The latest Census of Governments for which all data are available is the 1967; some data for the 1972 Census had been published by mid-February 1974, including those dealing with property values, but financial data on revenues, expenditures, and debt were not available in time to be used in this study. The latest "Governmental Finances" is for 1971-72, published early 1974, which deals with cities above 25,000 population.

The City and County Data Book gives the following financial data for cities above 25,000 population, based on 1969-70 data: general revenue total; intergovernmental revenue; taxes total; property taxes; sales and gross (tax) receipts; expenditures total; debt outstanding and expenditures on education; highways; public welfare; police and fire; and sanitation including sewerage.

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* Sales Management Survey of Buying Power, Part I, July 23, 1973, and Part II, October 29, 1973.

Data for places above 25,000 population in on the City and County Data Book computer tape and these data for municipal revenues, expenditures and debt outstanding were used in the classification analysis.

(5) Debt information sources are the same as for revenue data described above.

(6) Information on percentage sewered, existing treatment capital and industrial share of load is contained on the EPA 1973 Survey of Needs* computer tape. It has been possible to utilize these data in the classification analysis. Two important qualifications must be mentioned, however. Previous work with these data shows that they contain a large number of unuseable records and that the units of analysis, treatment facilities, are not necessarily comparable with the municipalities in the City and County Data Book. Consequently, contingency table analyses for these three characteristics are conducted using population data and municipality definitions from the Survey of Needs, not from the 1970 Census.

Classification Methodology Adopted

Because of the difficulties and expense associated with using the data sources described above, the analysis is made using the City and County Data Book computer tape and the 1973 Survey of Needs tape.+ The classification methodology adopted is based on the assumption that items (b) through (h) in the above list are functions of population size, and that within a given population group significant variation exists. To verify these assumptions, simple contingency table analysis* is performed on the following sets of variables:+

---

* "1973 Survey of Needs for Municipal Wastewater Treatment Facilities," Form EPA-1, Environmental Protection Agency.

+ The City and County Data Book tape excludes cities under 25,000 (56 percent of the population) and the Survey of Needs tape contains a large number of unuseable records. Results, therefore, must be viewed with these considerable limitations in mind. The conclusions, however, are made all the more dramatic by this exclusion of smaller communities with their higher unit costs of treatment.

a. Population (1970) vs. Growth Rate (1960-1970);

b. Population vs. Percent Low Income;

c. Population vs. Per Capita Expenditures;

d. Population vs. Per Capita Debt;

e. Population vs. Mediam Family Income;

f. Population vs. Per Capita Revenue;

g. Population vs. Percent of Families with Income "less than" X Dollars;

h. Population vs. Percent Sewered;

i. Population vs. Excess Treatment Capacity; and

j. Population vs. Industrial Share.

The existence of a significant relationship between population and one of the other variables is determined on the basis of the Chi-square statistic. The nature of the relationship is suggested by comparing the expected cell entry and the actual cell entry. The expected cell entry is a function of the marginal distributions of population and the dependent variable (e.g., population growth rate) and the total number of observations. The actual cell entry is the number of municipalities that fall into a certain cell defined by population size dependent variable value. The identification of a pattern of expected cell entry and actual cell entry differences may lead to some understanding of the nature of the relationship. The approach does not lead to an unambiguous interpretation, but it is helpful in identifying ways in which community size may be related to the other variables. The variation of a particular characteristic for a given population group can be ascertained from the percentage-of-row-total entries for the population group.

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* For a discussion of contingency table analysis and the use of the Chi-square statistic in such analysis, see, for example, Hoel, P. G., Introduction of Mathematical Statistics, John Wiley & Sons, Inc., New York, 1963 (3rd edition) pp. 252-255.

+ See "Definitions of Class Variables" below.

The contingency tables display, in a discrete format, the relationship between the independent variable (in all cases, population) and a characteristic or dependent variable, e.g., growth rate. Each row of a table represents a range of city sizes and each column a range of values for a particular dependent variable. For example, in Table 28, all the entries in the second row are cities with populations between 25,000 and 37,500. The sixth column in that table contains all entries for cities with a growth rate between zero percent and 5 percent. The last two rows of the table, labeled "PERCENT" and "TOTAL," are the marginal distribution and total number of entries in each growth rate category. The right most column of the table, labeled "TOTAL," contains the marginal distribution and number of cities in each population group.

The cells in a table contain four numbers:

1. the percent of row totals or the percentage of cities in a given size range which fall into a given dependent variable category;

2. percent of sub-table total or the percent of all cities in the sample which fall into a given dependent variable category;

3. expected values or the number of cities in a given size range which might be expected to fall in a certain dependent variable category if city size and the dependent variable were, in fact, independent; and

4. the number of cell entries or the number of cities in the sample in a given size range and a given dependent variable category.

For example, in Table 28 the cell delineated by the second row and the sixth column contains these numbers for cities between 25,000 and 37,500 with growth rates between zero percent and 5 percent. An examination of this cell indicates that 57.5 percent of the cities in this size range have growth rates between zero and 5 percent. Also, 20.5 percent of all cities in the sample are in this size range

Table 28.

```
                                               VAR(4)
                                               GROWTH RATE

                   >20%    >15%    >10%    > 5%    0-5%    0-5%    <10%    <15%    <20%    >20%
                   DEC     DEC     DEC     DEC     DEC*    INC     INC     INC     INC     INC**
                   1       2       3       4       5       6       7       8       9       10      TOTAL
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                 I       I       I       I       I       I100.0% I       I       I       I       I
                 I       I       I       I       I       I  0.1% I       I       I       I       I
       <25000    I   0.0I   0.0I   0.0I   0.0I   0.3I   0.6I   0.1I   0.0I   0.0I   0.0I
         1       I       I       I       I       I       I       I       I       I       I       I
                 I     0 I     0 I     0 I     0 I     0 I     1 I     0 I     0 I     0 I     0 I  0.1%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I     1
                 I       I       I       I       I 21.8% I 57.5% I 12.6% I  4.8% I  1.0% I  2.4% I
                 I       I       I       I       I  7.8% I 20.5% I  4.5% I  1.7% I  0.4% I  0.8% I
       <37500    I   0.0I   0.0I   0.0I   0.0I  77.0I 164.6I  30.3I  12.5I   4.3I   5.3I
         2       I       I       I       I       I       I       I       I       I       I       I
                 I     0 I     0 I     0 I     0 I    64 I   169 I    37 I    14 I     3 I     7 I 35.6%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I   294
                 I       I       I       I       I 20.1% I 66.9% I  6.5% I  2.6% I  2.6% I  1.3% I
                 I       I       I       I       I  3.8% I 12.5% I  1.2% I  0.5% I  0.5% I  0.2% I
       <50000    I   0.0I   0.0I   0.0I   0.0I  40.3I  86.2I  15.9I   6.5I   2.2I   2.8I
         3       I       I       I       I       I       I       I       I       I       I       I
VAR(9)           I     0 I     0 I     0 I     0 I    31 I   103 I    10 I     4 I     4 I     2 I 18.7%
POPULATION       I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I   154
                 I       I       I       I       I 26.0% I 52.6% I 12.3% I  6.5% I  0.6% I  1.9% I
                 I       I       I       I       I  4.8% I  9.8% I  2.3% I  1.2% I  0.1% I  0.4% I
       <75000    I   0.0I   0.0I   0.0I   0.0I  40.3I  86.2I  15.9I   6.5I   2.2I   2.8I
         4       I       I       I       I       I       I       I       I       I       I       I
                 I     0 I     0 I     0 I     0 I    40 I    81 I    19 I    10 I     1 I     3 I 18.7%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I   154
                 I       I       I       I       I 31.4% I 52.9% I  7.1% I  5.7% I  2.9% I       I
                 I       I       I       I       I  2.7% I  4.5% I  0.6% I  0.5% I  0.2% I       I
       <100000   I   0.0I   0.0I   0.0I   0.0I  18.3I  39.2I   7.2I   3.0I   1.0I   1.3I
         5       I       I       I       I       I       I       I       I       I       I       I
                 I     0 I     0 I     0 I     0 I    22 I    37 I     5 I     4 I     2 I     0 I  8.5%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I    70
                 I       I       I       I       I 34.9% I 44.4% I 15.9% I  1.6% I       I  3.2% I
                 I       I       I       I       I  2.7% I  3.4% I  1.2% I  0.1% I       I  0.2% I
       <150000   I   0.0I   0.0I   0.0I   0.0I  16.5I  35.3I   6.5I   2.7I   0.9I   1.1I
         6       I       I       I       I       I       I       I       I       I       I       I
                 I     0 I     0 I     0 I     0 I    22 I    28 I    10 I     1 I     0 I     2 I  7.6%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I    63
                 I       I       I       I       I 41.6% I 48.3% I  4.5% I  2.2% I  2.2% I  1.1% I
                 I       I       I       I       I  4.5% I  5.2% I  0.5% I  0.2% I  0.2% I  0.1% I
       >150000   I   0.0I   0.0I   0.0I   0.0I  23.3I  49.8I   9.2I   3.8I   1.3I   1.6I
         7       I       I       I       I       I       I       I       I       I       I       I
VAR(9)           I     0 I     0 I     0 I     0 I    37 I    43 I     4 I     2 I     2 I     1 I 10.8%
POPULATION       I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I    89

         PERCENT    0.0%    0.0%    0.0%    0.0%   26.2%   56.0%   10.3%    4.2%    1.5%    1.8% 100.0%
         TOTAL        0       0       0       0     216     462      85      35      12      15    825

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE                                44.616*     SIGNIFICANT AT .044 WITH 30 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                  825
NUMBER OF UNITS OMITTED DUE TO BLANKS            19
```

* DECREASE
**INCREASE

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and have growth rate within this range. In addition, if size and growth rate were independent, 104.6 cities would be expected to fall into this cell, whereas the actual number of cell entries is 169 or more than expected.

The other important numbers in the tables are the Chi-square statistic, level of significance and degrees of freedom. These appear in the row labeled, "CHI-SQUARE." In Table 28, for example, the Chi-square statistic has a value of 44.616 with a significance of .044 for 30 degrees of freedom. In other words, if growth rate and population size are independent, the probability of obtaining a Chi-square value of 44.616 with 30 degrees of freedom is .044.

In the interpretation of the contingency tables, the first number at which to look is the significance of the Chi-square statistic. If it is less than .01, it is reasonable to assume that there is some relationship between population and the dependent variable. If, on the basis of significance, a relationship is found, then examination of the expected values and the actual cell entries suggests what the nature of that relationship may be. For example, if the cells in the northwest portion and southeast portion of the contingency table showed positive differences between the actual cell entry and the expected cell values and the cells in the northeast and southwest showed negative differences, then it could be said that there was a positive relationship between the independent and dependent variables.

Results

The Chi-square statistic is significant at under the .001 level, with degrees of freedom ranging from 24-48, in all but four cases (see Table 29). The exceptions are for growth rate (.044, 30), percentage of families with income greater than $25,000 (.015, 42), percentage of population sewered (.422, 30), and percentage of industrial waste flow (.002, 30). Of this group the only truly insignificant relationship exists between community size and the percentage of population sewered.*

---

* Population figures in the 1973 Survey of Needs are known to be unreliable. Since it is that set of figures used in the construction of this contingency table, the unreliability of the data may be the cause of this result.

Table 29. CHI-SQUARE STATISTIC

Dependent Variable	Level of Significance	Degree of Freedom
Growth Rate	.044	30
Percent Low Income Families	<.001	24
Median Family Income	<.001	24
Percent with Income 3000	<.001	36
Percent with Income 3-5000	<.001	24
Percent with Income 5-7000	<.001	24
Per Capita Debt	<.001	30
Per Capita Revenue	<.001	36
Percent Sewered	.422	30
Excess Treatment Capacity	<.001	24
Percent Industrial Share	.002	30

With the highly significant Chi-square statistic in most cases, comparison of actual and expected cell entries suggests the following for places of over 25,000 population:

a. growth rate is inversely related to city size (Table 28);

b. the percentage of low income families in larger cities is higher than in smaller cities (Table 30);

c. more small cities than expected have high median family incomes (Table 31);

d. smaller cities demonstrate a greater spread in median family incomes than larger cities (Table 31);

e. smaller cities show a greater range in income than expected and larger cities show a smaller range than expected (Tables 32(a) through 32(c);

f. larger cities have a higher per capita debt than smaller cities (Table 33);

g. smaller cities have lower per capita revenues than larger cities (Table 34);

h. there appears to be no significant relationship between percent sewered and community size for communities of over 25,000 population (Table 35);

i. smaller cities tend to have more excess capacity than larger communities (Table 36);

j. more small communities than expected have a high industrial share and fewer moderate size communities than expected have a high industrial share (Table 37).

An examination of the percentage-of-row-total entries shows clearly that all of the characteristics, while depending on population in some fashion, demonstrate rather significant variations within given population groups.

Table 30.

```
                                                           VAR(6)
                                                           % LOW INCOME FAMILIES
                   <10     <20     <30     <40     <50     <60     <70     <80     <90     <100

                    1       2       3       4       5       6       7       8       9       10     TOTAL
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                 I100.0% I       I       I       I       I       I       I       I       I       I
                 I  0.1% I       I       I       I       I       I       I       I       I       I
                 I    0.7I    0.3I    0.0I    0.0I    0.0I    0.0I    0.0I    0.0I    0.0I    0.0I
        <25000   I       I       I       I       I       I       I       I       I       I       I
          1      I       I       I       I       I       I       I       I       I       I       I
                 I     1 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I   0.1%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I     1
                 I 73.4% I 22.3% I  4.0% I  0.3% I       I       I       I       I       I       I
                 I 26.2% I  7.9% I  1.4% I  0.1% I       I       I       I       I       I       I
                 I  208.3I   82.4I    8.9I    1.1I    0.4I    0.0I    0.0I    0.0I    0.0I    0.0I
        <37500   I       I       I       I       I       I       I       I       I       I       I
          2      I       I       I       I       I       I       I       I       I       I       I
                 I   221 I    67 I    12 I     1 I     0 I     0 I     0 I     0 I     0 I     0 I  35.7%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I   301
                 I 72.7% I 22.7% I  3.9% I  0.6% I       I       I       I       I       I       I
                 I 13.3% I  4.1% I  0.7% I  0.1% I       I       I       I       I       I       I
                 I  106.6I   42.1I    4.6I    0.5I    0.2I    0.0I    0.0I    0.0I    0.0I    0.0I
        <50000   I       I       I       I       I       I       I       I       I       I       I
          3      I       I       I       I       I       I       I       I       I       I       I
VAR(9)           I       I       I       I       I       I       I       I       I       I       I
POPULATION       I   112 I    35 I     6 I     1 I     0 I     0 I     0 I     0 I     0 I     0 I  18.2%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I   154
                 I 71.8% I 23.7% I  3.2% I  0.6% I  0.6% I       I       I       I       I       I
                 I 13.3% I  4.4% I  0.6% I  0.1% I  0.1% I       I       I       I       I       I
                 I  107.9I   42.7I    4.6I    0.6I    0.2I    0.0I    0.0I    0.0I    0.0I    0.0I
        <75000   I       I       I       I       I       I       I       I       I       I       I
          4      I       I       I       I       I       I       I       I       I       I       I
                 I   112 I    37 I     5 I     1 I     1 I     0 I     0 I     0 I     0 I     0 I  18.5%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I   156
                 I 77.3% I 22.7% I       I       I       I       I       I       I       I       I
                 I  6.9% I  2.0% I       I       I       I       I       I       I       I       I
                 I   51.9I   20.5I    2.2I    0.3I    0.1I    0.0I    0.0I    0.0I    0.0I    0.0I
        <100000  I       I       I       I       I       I       I       I       I       I       I
          5      I       I       I       I       I       I       I       I       I       I       I
                 I    58 I    17 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I   8.9%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I    75
                 I 63.5% I 34.9% I  1.6% I       I       I       I       I       I       I       I
                 I  4.7% I  2.6% I  0.1% I       I       I       I       I       I       I       I
                 I   43.6I   17.2I    1.9I    0.2I    0.1I    0.0I    0.0I    0.0I    0.0I    0.0I
        <150000  I       I       I       I       I       I       I       I       I       I       I
          6      I       I       I       I       I       I       I       I       I       I       I
                 I    40 I    22 I     1 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I   7.5%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I    63
                 I 42.6% I 56.4% I  1.1% I       I       I       I       I       I       I       I
                 I  4.7% I  6.3% I  0.1% I       I       I       I       I       I       I       I
                 I   65.0I   25.7I    2.8I    0.3I    0.1I    0.0I    0.0I    0.0I    0.0I    0.0I
        >150000  I       I       I       I       I       I       I       I       I       I       I
          7      I       I       I       I       I       I       I       I       I       I       I
VAR(9)           I       I       I       I       I       I       I       I       I       I       I
POPULATION       I    40 I    53 I     1 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I  11.1%
                 I-------I-------I-------I-------I-------I-------I-------I-------I-------I-------I    94

         PERCENT   69.2%   27.4%    3.0%    0.4%    0.1%    0.0%    0.0%    0.0%    0.0%    0.0%  100.0%
         TOTAL      584     231      25       3       1       0       0       0       0       0     844

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE                         59.266000    SIGNIFICANCE UNDER .001 WITH 24 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE            844
```

Table 31.

```
                                                     VAR(10)
                                                     MEDIAN FAMILY INCOME

                           <3000   <5000   <7000   <10000  <15000  <25000  >25000

                             1       2       3       4       5       6       7      TOTAL
                         I-------I-------I-------I-------I-------I-------I-------I
                         I       I       I       I       I100.0% I       I       I
                         I       I       I       I       I 0.1%  I       I       I
                         I   0.0 I   0.0 I   0.0 I   0.5 I   0.5 I   0.0 I   0.0 I
              <25000     I       I       I       I       I       I       I       I
                1        I       I       I       I       I       I       I       I    0.1%
                         I     0 I     0 I     0 I     0 I     1 I     0 I     0 I    1
                         I-------I-------I-------I-------I-------I-------I-------I
                         I       I       I  4.3% I 41.2% I 48.2% I  6.3% I       I
                         I       I       I  1.5% I 14.7% I 17.2% I  2.3% I       I
                         I   0.0 I   0.7 I   9.3 I 143.0 I 136.9 I  11.1 I   0.0 I
              <37500     I       I       I       I       I       I       I       I
                2        I       I       I       I       I       I       I       I   35.7%
                         I     0 I     0 I    13 I   124 I   145 I    19 I     0 I   301
                         I-------I-------I-------I-------I-------I-------I-------I
                         I       I       I  6.5% I 50.0% I 40.3% I  3.2% I       I
                         I       I       I  1.2% I  9.1% I  7.3% I  0.6% I       I
                         I   0.0 I   0.4 I   4.7 I  73.2 I  70.1 I   5.7 I   0.0 I
              <50000     I       I       I       I       I       I       I       I
                3        I       I       I       I       I       I       I       I   18.2%
VAR(9)                   I     0 I     0 I    10 I    77 I    62 I     5 I     0 I   154
POPULATION               I-------I-------I-------I-------I-------I-------I-------I
                         I       I  1.3% I  1.9% I 42.3% I 51.3% I  3.2% I       I
                         I       I  0.2% I  0.4% I  7.8% I  9.5% I  0.6% I       I
                         I   0.0 I   0.4 I   4.8 I  74.1 I  71.0 I   5.7 I   0.0 I
              <75000     I       I       I       I       I       I       I       I
                4        I       I       I       I       I       I       I       I   18.5%
                         I     0 I     2 I     3 I    66 I    80 I     5 I     0 I   156
                         I-------I-------I-------I-------I-------I-------I-------I
                         I       I       I       I 41.3% I 57.3% I  1.3% I       I
                         I       I       I       I  3.7% I  5.1% I  0.1% I       I
                         I   0.0 I   0.2 I   2.3 I  35.6 I  34.1 I   2.8 I   0.0 I
              <100000    I       I       I       I       I       I       I       I
                5        I       I       I       I       I       I       I       I    8.9%
                         I     0 I     0 I     0 I    31 I    43 I     1 I     0 I    75
                         I-------I-------I-------I-------I-------I-------I-------I
                         I       I       I       I 60.3% I 38.1% I  1.6% I       I
                         I       I       I       I  4.5% I  2.8% I  0.1% I       I
                         I   0.0 I   0.1 I   1.9 I  29.9 I  26.7 I   2.3 I   0.0 I
              <150000    I       I       I       I       I       I       I       I
                6        I       I       I       I       I       I       I       I    7.5%
                         I     0 I     0 I     0 I    38 I    24 I     1 I     0 I    63
                         I-------I-------I-------I-------I-------I-------I-------I
                         I       I       I       I 69.1% I 30.9% I       I       I
                         I       I       I       I  7.7% I  3.4% I       I       I
                         I   0.0 I   0.2 I   2.9 I  44.7 I  42.6 I   3.5 I   0.0 I
              >150000    I       I       I       I       I       I       I       I
                7        I       I       I       I       I       I       I       I   11.1%
VAR(9)                   I     0 I     0 I     0 I    65 I    29 I     0 I     0 I    94
POPULATION               I-------I-------I-------I-------I-------I-------I-------I

                 PERCENT    0.0%    0.2%    3.1%   47.5%   45.5%    3.7%    0.0%  100.0%
                 TOTAL      0       2       26     401     384      31      0      844

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE . . . . . . . . . . .   62.059***    SIGNIFICANCE UNDER .001 WITH 24 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                 844
```

Table 32(a).

```
                                                          VAR(12)
                                                          % WITH INCOME < 3000$

                   0-5%    5-10%   10-15%  15-20%  20-25%  25-30%  30-35%  35-40%  >40%

                   1       2       3       4       5       6       7       8       9        TOTAL
                  I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I       I100.0% I       I       I       I       I       I       I       I
                  I       I  0.1% I       I       I       I       I       I       I       I
                  I    0.2I    0.5I    0.2I    0.1I    0.0I    0.0I    0.0I    0.0I    0.0I
         <25000   I       I       I       I       I       I       I       I       I       I
           1      I       I       I       I       I       I       I       I       I       I   0.1%
                  I     0 I     1 I     0 I     0 I     0 I     0 I     0 I     0 I     0 I     1
                  I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I 31.6% I 41.2% I 16.9% I  8.0% I  2.3% I       I       I       I       I
                  I 11.3% I 14.7% I  6.0% I  2.8% I  0.8% I       I       I       I       I
                  I   69.9I  141.2I   66.3I   17.8I    5.0I    0.4I    0.4I    0.0I    0.0I
         <37500   I       I       I       I       I       I       I       I       I       I
           2      I       I       I       I       I       I       I       I       I       I  35.7%
                  I    95 I   124 I    51 I    24 I     7 I     0 I     0 I     0 I     0 I   301
                  I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I 19.5% I 51.3% I 20.8% I  5.8% I  2.6% I       I       I       I       I
                  I  3.6% I  9.4% I  3.8% I  1.1% I  0.5% I       I       I       I       I
                  I   35.8I   72.3I   33.9I    9.1I    2.6I    0.2I    0.2I    0.0I    0.0I
         <50000   I       I       I       I       I       I       I       I       I       I
           3      I       I       I       I       I       I       I       I       I       I  18.2%
VAR(9)            I    30 I    79 I    32 I     9 I     4 I     0 I     0 I     0 I     0 I   154
POPULATION        I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I 24.4% I 47.4% I 19.9% I  5.1% I  1.9% I  0.6% I  0.6% I       I       I
                  I  4.5% I  8.8% I  3.7% I  0.9% I  0.4% I  0.1% I  0.1% I       I       I
                  I   36.2I   73.2I   34.4I    9.2I    2.6I    0.2I    0.2I    0.0I    0.0I
         <75000   I       I       I       I       I       I       I       I       I       I
           4      I       I       I       I       I       I       I       I       I       I  18.5%
                  I    38 I    74 I    31 I     8 I     3 I     1 I     1 I     0 I     0 I   156
                  I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I 32.0% I 49.3% I 17.3% I  1.3% I       I       I       I       I       I
                  I  2.8% I  4.4% I  1.5% I  0.1% I       I       I       I       I       I
                  I   17.4I   35.2I   16.5I    4.4I    1.2I    0.1I    0.1I    0.0I    0.0I
         <100000  I       I       I       I       I       I       I       I       I       I
           5      I       I       I       I       I       I       I       I       I       I   8.9%
                  I    24 I    37 I    13 I     1 I     0 I     0 I     0 I     0 I     0 I    75
                  I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I 12.7% I 50.8% I 30.2% I  6.3% I       I       I       I       I       I
                  I  0.9% I  3.8% I  2.3% I  0.5% I       I       I       I       I       I
                  I   14.6I   29.6I   13.9I    3.7I    1.0I    0.1I    0.1I    0.0I    0.0I
         <150000  I       I       I       I       I       I       I       I       I       I
           6      I       I       I       I       I       I       I       I       I       I   7.5%
                  I     8 I    32 I    19 I     4 I     0 I     0 I     0 I     0 I     0 I    63
                  I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                  I  1.1% I 52.1% I 42.6% I  4.3% I       I       I       I       I       I
                  I  0.1% I  5.8% I  4.7% I  0.5% I       I       I       I       I       I
                  I   21.8I   44.1I   20.7I    5.6I    1.6I    0.1I    0.1I    0.0I    0.0I
         >150000  I       I       I       I       I       I       I       I       I       I
           7      I       I       I       I       I       I       I       I       I       I  11.1%
VAR(9)            I     1 I    49 I    40 I     4 I     0 I     0 I     0 I     0 I     0 I    94
POPULATION        I-------I-------I-------I-------I-------I-------I-------I-------I-------I

         PERCENT    23.2%   46.9%   22.0%    5.9%    1.7%    0.1%    0.1%    0.0%    0.0% 100.0%
         TOTAL       196     396     186      50      14       1       1       0       0    844

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE.................................84.461000     SIGNIFICANCE UNDER .001 WITH 36 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                  844
```

Table 32(b).

```
                                                                VAR(13)
                                                                % WITH INCOME 3000-4999$

                                0-5%     5-10%    10-15%   15-20%   20-25%   25-30%   30-35%   35-40%   >40%

                                1        2        3        4        5        6        7        8        9        TOTAL
                              I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I        I100.0%  I        I        I        I        I        I        I        I
                              I        I  0.1%  I        I        I        I        I        I        I        I
                              I     0.2I     0.5I     0.3I     0.1I     0.0I     0.0I     0.0I     0.0I     0.0I
                <25000        I        I        I        I        I        I        I        I        I        I   0.1%
                  1           I        I        I        I        I        I        I        I        I        I    1
                              I      0 I      1 I      0 I      0 I      0 I      0 I      0 I      0 I      0 I
                              I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I 26.2%  I 39.9%  I 24.9%  I  8.3%  I  0.7%  I        I        I        I        I
                              I  9.4%  I 14.2%  I  8.9%  I  3.0%  I  0.2%  I        I        I        I        I
                              I    51.7I   137.3I    93.1I    17.5I     1.4I     0.0I     0.0I     0.0I     0.0I
                <37500        I        I        I        I        I        I        I        I        I        I  35.7%
                  2           I        I        I        I        I        I        I        I        I        I   301
                              I     79 I    120 I     75 I     25 I      2 I      0 I      0 I      0 I      0 I
                              I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I 13.6%  I 46.8%  I 31.2%  I  7.8%  I  0.6%  I        I        I        I        I
                              I  2.5%  I  8.5%  I  5.7%  I  1.4%  I  0.1%  I        I        I        I        I
                              I    26.5I    70.2I    47.6I     8.9I     0.7I     0.0I     0.0I     0.0I     0.0I
                <50000        I        I        I        I        I        I        I        I        I        I  18.2%
                  3           I        I        I        I        I        I        I        I        I        I   154
VAR(9)                        I     21 I     72 I     48 I     12 I      1 I      0 I      0 I      0 I      0 I
POPULATION                    I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I 14.1%  I 50.6%  I 30.1%  I  4.5%  I  0.6%  I        I        I        I        I
                              I  2.6%  I  9.4%  I  5.6%  I  0.8%  I  0.1%  I        I        I        I        I
                              I    26.8I    71.2I    48.2I     9.1I     0.7I     0.0I     0.0I     0.0I     0.0I
                <75000        I        I        I        I        I        I        I        I        I        I  18.5%
                  4           I        I        I        I        I        I        I        I        I        I   156
                              I     22 I     79 I     47 I      7 I      1 I      0 I      0 I      0 I      0 I
                              I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I 21.3%  I 56.0%  I 20.0%  I  2.7%  I        I        I        I        I        I
                              I  1.9%  I  5.0%  I  1.8%  I  0.2%  I        I        I        I        I        I
                              I    12.9I    34.2I    23.2I     4.4I     0.4I     0.0I     0.0I     0.0I     0.0I
                <100000       I        I        I        I        I        I        I        I        I        I   8.9%
                  5           I        I        I        I        I        I        I        I        I        I    75
                              I     16 I     42 I     15 I      2 I      0 I      0 I      0 I      0 I      0 I
                              I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I  9.5%  I 44.4%  I 44.4%  I  1.6%  I        I        I        I        I        I
                              I  0.7%  I  3.3%  I  3.3%  I  0.1%  I        I        I        I        I        I
                              I    10.8I    28.7I    19.5I     3.7I     0.3I     0.0I     0.0I     0.0I     0.0I
                <150000       I        I        I        I        I        I        I        I        I        I   7.5%
                  6           I        I        I        I        I        I        I        I        I        I    63
                              I      6 I     28 I     28 I      1 I      0 I      0 I      0 I      0 I      0 I
                              I--------I--------I--------I--------I--------I--------I--------I--------I--------I
                              I  1.1%  I 45.7%  I 51.1%  I  2.1%  I        I        I        I        I        I
                              I  0.1%  I  5.1%  I  5.7%  I  0.2%  I        I        I        I        I        I
                              I    16.1I    42.9I    29.1I     5.5I     0.4I     0.0I     0.0I     0.0I     0.0I
                >150000       I        I        I        I        I        I        I        I        I        I  11.1%
                  7           I        I        I        I        I        I        I        I        I        I    94
VAR(9)                        I      1 I     43 I     48 I      2 I      0 I      0 I      0 I      0 I      0 I
POPULATION                    I--------I--------I--------I--------I--------I--------I--------I--------I--------I

                    PERCENT     17.2%    45.6%    30.9%    5.8%     0.5%     0.0%     0.0%     0.0%     0.0%   100.0%
                    TOTAL       145      385      261      49       4        0        0        0        0      844

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE                                73.732***    SIGNIFICANCE UNDER .001 WITH 24 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                          844
```

Table 32(c).

```
                                                     VAR(14)
                                                     % WITH INCOME 5000-6999$

                     0-5%    5-10%   10-15%  15-20%  20-25%  25-30%  30-35%  35-40%  >40%

                     1       2       3       4       5       6       7       8       9        TOTAL
                    I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I       I100.0% I       I       I       I       I       I       I       I
                    I       I  0.1% I       I       I       I       I       I       I       I
                    I    0.1I    0.3I    0.5I    0.1I    0.0I    0.0I    0.0I    0.0I    0.0I
           <25000   I       I       I       I       I       I       I       I       I       I
              1     I       I       I       I       I       I       I       I       I       I   0.1%
                    I      0I      1I      0I      0I      0I      0I      0I      0I      0I     1
                    I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I 15.9% I 29.2% I 39.9% I 14.3% I  0.7% I       I       I       I       I
                    I  5.7% I 10.4% I 14.2% I  5.1% I  0.2% I       I       I       I       I
                    I   26.0I   92.0I  144.8I   37.1I    1.1I    0.0I    0.0I    0.0I    0.0I
           <37500   I       I       I       I       I       I       I       I       I       I
              2     I       I       I       I       I       I       I       I       I       I  35.7%
                    I     48I     88I    120I     43I      2I      0I      0I      0I      0I   301
                    I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I  5.8% I 29.2% I 51.9% I 12.3% I  0.6% I       I       I       I       I
                    I  1.1% I  5.3% I  9.5% I  2.3% I  0.1% I       I       I       I       I
                    I   13.3I   47.1I   74.1I   19.0I    0.5I    0.0I    0.0I    0.0I    0.0I
           <50000   I       I       I       I       I       I       I       I       I       I
              3     I       I       I       I       I       I       I       I       I       I  18.2%
VAR(9)              I      9I     45I     80I     19I      1I      0I      0I      0I      0I   154
POPULATION          I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I  5.8% I 35.9% I 45.5% I 12.8% I       I       I       I       I       I
                    I  1.1% I  6.6% I  8.4% I  2.4% I       I       I       I       I       I
                    I   13.5I   47.7I   75.0I   19.2I    0.6I    0.0I    0.0I    0.0I    0.0I
           <75000   I       I       I       I       I       I       I       I       I       I
              4     I       I       I       I       I       I       I       I       I       I  18.5%
                    I      9I     56I     71I     20I      0I      0I      0I      0I      0I   156
                    I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I  4.0% I 50.7% I 37.3% I  8.0% I       I       I       I       I       I
                    I  0.4% I  4.5% I  3.3% I  0.7% I       I       I       I       I       I
                    I    6.5I   22.9I   36.1I    9.2I    0.3I    0.0I    0.0I    0.0I    0.0I
          <100000   I       I       I       I       I       I       I       I       I       I
              5     I       I       I       I       I       I       I       I       I       I   8.9%
                    I      3I     38I     28I      6I      0I      0I      0I      0I      0I    75
                    I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I  4.8% I 25.4% I 58.7% I 11.1% I       I       I       I       I       I
                    I  0.4% I  1.9% I  4.4% I  0.8% I       I       I       I       I       I
                    I    5.4I   19.3I   30.3I    7.8I    0.2I    0.0I    0.0I    0.0I    0.0I
          <150000   I       I       I       I       I       I       I       I       I       I
              6     I       I       I       I       I       I       I       I       I       I   7.5%
                    I      3I     16I     37I      7I      0I      0I      0I      0I      0I    63
                    I-------I-------I-------I-------I-------I-------I-------I-------I-------I
                    I  1.1% I 14.9% I 74.5% I  9.6% I       I       I       I       I       I
                    I  0.1% I  1.7% I  8.3% I  1.1% I       I       I       I       I       I
                    I    8.1I   28.7I   45.2I   11.6I    0.3I    0.0I    0.0I    0.0I    0.0I
          >150000   I       I       I       I       I       I       I       I       I       I
              7     I       I       I       I       I       I       I       I       I       I  11.1%
VAR(9)              I      1I     14I     70I      9I      0I      0I      0I      0I      0I    94
POPULATION          I-------I-------I-------I-------I-------I-------I-------I-------I-------I

             PERCENT   8.6%   30.6%   48.1%   12.3%    0.4%    0.0%    0.0%    0.0%    0.0% 100.0%
             TOTAL      73     258     406     104       3       0       0       0       0    844
UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE                            79.78744    SIGNIFICANCE UNDER .001 WITH 24 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE              844
```

Table 33.

```
                                        VAR(F)
                                        PER CAPITA DEBT

                          <250$    <500$    <750$    <1000$   <1500$   1500$
                                                                       & OVER
                          1        2        3        4        5        6        TOTAL
                         I--------I--------I--------I--------I--------I--------I
                         I100.0%  I        I        I        I        I        I
                         I  0.1%  I        I        I        I        I        I
                         I    0.6I     0.3I     0.1I     0.0I     0.0I     0.0I
              <250C0     I        I        I        I        I        I        I
                 1       I        I        I        I        I        I        I   0.1%
                         I      1 I      0 I      0 I      0 I      0 I      0 I     1
                         I--------I--------I--------I--------I--------I--------I
                         I 66.9%  I 25.3%  I  4.5%  I  1.5%  I  0.7%  I  1.1%  I
                         I 22.4%  I  8.4%  I  1.5%  I  0.5%  I  0.2%  I  0.4%  I
                         I  160.4I    77.5I    22.4I     5.0I     1.7I     2.0I
              <37500     I        I        I        I        I        I        I
                 2       I        I        I        I        I        I        I  33.4%
                         I    180 I     68 I     12 I      4 I      2 I      3 I   269
                         I--------I--------I--------I--------I--------I--------I
                         I 67.1%  I 23.0%  I  5.9%  I  2.0%  I  1.3%  I  0.7%  I
                         I 12.7%  I  4.3%  I  1.1%  I  0.4%  I  0.2%  I  0.1%  I
                         I   90.6I    43.8I    12.7I     2.8I     0.9I     1.1I
              <50000     I        I        I        I        I        I        I
                 3       I        I        I        I        I        I        I  18.9%
VAR(V)                   I    102 I     35 I      9 I      3 I      2 I      1 I   152
POPULATION               I--------I--------I--------I--------I--------I--------I
                         I 62.2%  I 28.8%  I  6.4%  I  1.3%  I  0.6%  I  0.6%  I
                         I 12.0%  I  5.6%  I  1.2%  I  0.2%  I  0.1%  I  0.1%  I
                         I   93.0I    45.0I    13.0I     2.9I     1.0I     1.2I
              <75000     I        I        I        I        I        I        I
                 4       I        I        I        I        I        I        I  19.4%
                         I     97 I     45 I     10 I      2 I      1 I      1 I   156
                         I--------I--------I--------I--------I--------I--------I
                         I 58.7%  I 28.0%  I  9.3%  I  4.0%  I        I        I
                         I  5.5%  I  2.6%  I  0.9%  I  0.4%  I        I        I
                         I   44.7I    21.6I     6.2I     1.4I     0.5I     0.6I
              <100000    I        I        I        I        I        I        I
                 5       I        I        I        I        I        I        I   9.3%
                         I     44 I     21 I      7 I      3 I      0 I      0 I    75
                         I--------I--------I--------I--------I--------I--------I
                         I 55.6%  I 31.7%  I  9.5%  I  3.2%  I        I        I
                         I  4.3%  I  2.5%  I  0.7%  I  0.2%  I        I        I
                         I   37.6I    18.2I     5.2I     1.2I     0.4I     0.5I
              <150000    I        I        I        I        I        I        I
                 6       I        I        I        I        I        I        I   7.8%
                         I     35 I     20 I      6 I      2 I      0 I      0 I    63
                         I--------I--------I--------I--------I--------I--------I
                         I 23.6%  I 48.3%  I 25.8%  I  1.1%  I        I  1.1%  I
                         I  2.6%  I  5.3%  I  2.9%  I  0.1%  I        I  0.1%  I
                         I   53.1I    25.6I     7.4I     1.7I     0.6I     0.7I
              >150000    I        I        I        I        I        I        I
                 7       I        I        I        I        I        I        I  11.1%
VAR(S)                   I     21 I     43 I     23 I      1 I      0 I      1 I    89
POPULATION               I--------I--------I--------I--------I--------I--------I

                 PERCENT    59.6%    28.8%     8.3%     1.9%     0.6%     0.7%  100.0%
                 TOTAL      480      232       67       15        5        6     805

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
                       PERCENT OF SUB-TABLE TOTAL
                       EXPECTED VALUES

CHI-SQUARE                               86.25900    SIGNIFICANCE UNDER .001 WITH 30 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                 805
NUMBER OF UNITS OMITTED DUE TO BLANKS           39
```

Table 34.

VAR(11)
PER CAPITA REVENUE

VAR(9) POPULATION	<500$ 1	<1000$ 2	<1500$ 3	<2000$ 4	<2500$ 5	<3000$ 6	>3000$ 7	TOTAL
<25000 1	0.0 0	0.3 0	100.0% 0.1% 0.3 1	0.1 0	0.1 0	0.1 0	0.1 0	0.1% 1
<37500 2	4.1% 1.4% 6.3 11	40.5% 13.5% 79.9 109	27.9% 9.3% 84.9 75	9.7% 3.2% 31.4 26	5.2% 1.7% 16.0 14	4.8% 1.6% 14.7 13	7.8% 2.6% 35.8 21	33.4% 269
<50000 3	1.3% 0.2% 3.6 2	34.9% 6.6% 45.1 53	27.6% 5.2% 48.0 42	9.9% 1.9% 17.7 15	7.9% 1.5% 9.1 12	3.9% 0.7% 8.3 6	14.5% 2.7% 20.2 22	18.9% 152
<75000 4	1.9% 0.4% 3.7 3	28.8% 5.6% 46.3 45	39.7% 7.7% 49.2 62	8.3% 1.6% 18.2 13	5.8% 1.1% 9.3 9	4.5% 0.9% 8.5 7	10.9% 2.1% 20.7 17	19.4% 156
<100000 5	4.0% 0.4% 1.8 3	24.0% 2.2% 22.3 18	25.3% 2.4% 23.7 19	13.3% 1.2% 8.8 10	5.3% 0.5% 4.5 4	9.3% 0.9% 4.1 7	18.7% 1.7% 10.0 14	9.3% 75
<150000 6	1.5 0	15.9% 1.2% 18.7 10	36.5% 2.9% 19.9 23	20.6% 1.6% 7.4 13	3.2% 0.2% 3.8 2	6.3% 0.5% 3.4 4	17.5% 1.4% 8.4 11	7.8% 63
>150000 7	2.1 0	4.5% 0.5% 26.4 4	36.0% 4.0% 28.1 32	19.1% 2.1% 10.4 17	7.9% 0.9% 5.3 7	7.9% 0.9% 4.9 7	24.7% 2.7% 11.8 22	11.1% 89
PERCENT TOTAL	2.4% 19	29.7% 239	31.6% 254	11.7% 94	6.0% 48	5.5% 44	13.3% 107	100.0% 805

UPPER CELL ENTRIES ARE PERCENT OF ROW TOTALS
PERCENT OF SUB-TABLE TOTAL
EXPECTED VALUES

CHI-SQUARE 90.445000 SIGNIFICANCE UNDER .001 WITH 36 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE 805
NUMBER OF UNITS OMITTED DUE TO BLANKS 39

Table 35.

```
                                      VAR121
                                      PER CENT SEWERED

                       0-50%   50-60%  60-70%  70-80%  80-90%  90-100
                                                               I
                        1       2       3       4       5       6      TOTAL
                       I-------I-------I-------I-------I-------I-------I
                       I  8.6% I  2.5% I  2.3% I  3.2% I  5.3% I 78.2% I
                       I 152.7 I  43.0 I  42.2 I  65.8 I  93.4 I1378.9 I
            <25000     I       I       I       I       I       I       I  81.2%
               1       I   152 I    44 I    41 I    56 I    94 I  1389 I  1776
                       I-------I-------I-------I-------I-------I-------I
                       I  6.4% I       I  2.4% I  6.4% I  6.4% I 78.4% I
                       I  10.7 I   3.0 I   3.0 I   4.6 I   6.6 I  97.1 I
            <37500     I       I       I       I       I       I       I   5.7%
               2       I     8 I     0 I     3 I     8 I     8 I    98 I   125
                       I-------I-------I-------I-------I-------I-------I
                       I  7.7% I  3.8% I  5.8% I  7.7% I  3.8% I 71.2% I
                       I   4.5 I   1.3 I   1.2 I   1.9 I   2.7 I  40.4 I
            <50000     I       I       I       I       I       I       I   2.4%
               3       I     4 I     2 I     3 I     4 I     2 I    37 I    52
                       I-------I-------I-------I-------I-------I-------I
                       I 10.5% I  3.9% I       I  3.9% I  2.6% I 78.9% I
                       I   6.5 I   1.8 I   1.8 I   2.8 I   4.0 I  59.0 I
            <75000     I       I       I       I       I       I       I   3.5%
               4       I     8 I     3 I     0 I     3 I     2 I    60 I    76
VAR133                 I-------I-------I-------I-------I-------I-------I
POPULATION             I  7.9% I  2.6% I       I  5.3% I  5.3% I 78.9% I
                       I   3.3 I   0.9 I   0.9 I   1.4 I   2.0 I  29.5 I
            <100000    I       I       I       I       I       I       I   1.7%
               5       I     3 I     1 I     0 I     2 I     2 I    30 I    38
                       I-------I-------I-------I-------I-------I-------I
                       I 12.1% I       I  6.1% I 12.1% I  6.1% I 63.6% I
                       I   2.8 I   0.8 I   0.8 I   1.2 I   1.7 I  25.6 I
            <150000    I       I       I       I       I       I       I   1.5%
               6       I     4 I     0 I     2 I     4 I     2 I    21 I    33
                       I-------I-------I-------I-------I-------I-------I
                       I 10.3% I  3.4% I  3.4% I  4.6% I  5.7% I 72.4% I
                       I   7.5 I   2.1 I   2.1 I   3.2 I   4.6 I  67.5 I
            >150000    I       I       I       I       I       I       I   4.0%
               7       I     9 I     3 I     3 I     4 I     5 I    63 I    87
                       I-------I-------I-------I-------I-------I-------I

               PERCENT    8.6%    2.4%    2.4%    3.7%    5.3%   77.6%  100.0%
               TOTAL      188      53      52      81     115    1698    2187

CHI-SQUARE                        30.870        SIGNIFICANT AT .422 WITH 30 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                  2187
NUMBER OF UNITS OMITTED DUE TO BLANKS          11661
```

Table 36.

```
                                                 VAR(4)
                                                 EXCESS CAPACITY
                              >100%   >50%    0-50%   <50%    <100%   >100%
                              DEF     DEF     DEF     EXCESS  EXCESS  EXCESS
                              1       2       3       4       5       6       TOTAL
                            I-------I-------I-------I-------I-------I-------I
                            I       I  3.0I I 14.4I I 49.6I I 14.7I I 18.2I I
                  <25000    I   0.0I  214.0I  964.3I 3072.2I  918.4I 1101.2I
                     1      I       I       I       I       I       I       I  86.6I
                            I     0 I   190 I   903 I  3109 I   924 I  1144 I  6270
                            I-------I-------I-------I-------I-------I-------I
                            I       I  4.9I I 18.8I I 46.9I I 14.2I I 15.2I I
                  <37500    I   0.0I   10.5I   47.5I  151.4I   45.3I   54.3I
                     2      I       I       I       I       I       I       I   4.3I
                            I     0 I    15 I    58 I   145 I    44 I    47 I   309
                            I-------I-------I-------I-------I-------I-------I
                            I       I  2.9I I 21.3I I 47.1I I 17.6I I 11.0I I
                  <50000    I   0.0I    4.6I   20.9I   66.6I   19.9I   23.9I
                     3      I       I       I       I       I       I       I   1.9I
                            I     0 I     4 I    29 I    64 I    24 I    15 I   136
                            I-------I-------I-------I-------I-------I-------I
                            I       I  6.3I I 20.6I I 45.0I I  9.0I I 19.0I I
                  <75000    I   0.0I    6.5I   29.1I   92.6I   27.7I   33.2I
VAR( 3)              4      I       I       I       I       I       I       I   2.6I
POPULATION                  I     0 I    12 I    39 I    85 I    17 I    36 I   189
                            I-------I-------I-------I-------I-------I-------I
                            I       I  7.5I I 22.6I I 37.6I I 19.4I I 12.9I I
                  <100000   I   0.0I    3.2I   14.3I   45.6I   13.6I   16.3I
                     5      I       I       I       I       I       I       I   1.3I
                            I     0 I     7 I    21 I    35 I    18 I    12 I    93
                            I-------I-------I-------I-------I-------I-------I
                            I       I  6.8I I 18.2I I 48.9I I 14.8I I 11.4I I
                  <150000   I   0.0I    3.0I   13.5I   43.1I   12.9I   15.5I
                     6      I       I       I       I       I       I       I   1.2I
                            I     0 I     6 I    16 I    43 I    13 I    10 I    88
                            I-------I-------I-------I-------I-------I-------I
                            I       I  8.6I I 30.9I I 42.8I I 13.2I I  4.6I I
                  >150000   I   0.0I    5.2I   23.4I   74.5I   22.3I   26.7I
                     7      I       I       I       I       I       I       I   2.1I
                            I     0 I    13 I    47 I    65 I    20 I     7 I   152
                            I-------I-------I-------I-------I-------I-------I
                  PERCENT       0.0I    3.4I   15.4I   49.0I   14.6I   17.6I 100.0I
                  TOTAL            0     247    1113    3546    1060    1271   7237
CHI-SQUARE
                                        104.506***     SIGNIFICANCE UNDER .001 WITH 24 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE                          7237
NUMBER OF UNITS OMITTED DUE TO BLANKS                   6411
```

Table 37.

VAR(5)
INDUSTRIAL SHARE

VAR(1) POPULATION	0-10% 1	10-20% 2	20-30% 3	30-40% 4	40-50% 5	>50% 6	TOTAL
<25000 1	30.1% 474.3 468	23.0% 361.2 357	14.7% 238.2 229	9.3% 156.7 144	7.2% 111.7 112	15.8% 212.9 245	70.3% 1555
<37500 2	33.7% 58.0 64	23.7% 44.1 45	18.9% 29.1 36	11.6% 19.1 22	4.2% 13.7 8	7.9% 26.0 15	8.6% 190
<50000 3	36.0% 26.2 31	17.4% 20.0 15	22.1% 13.2 19	11.6% 8.7 10	5.8% 6.2 5	7.0% 11.8 6	3.9% 86
<75000 4	39.0% 36.0 46	24.6% 27.4 29	13.6% 18.1 16	14.4% 11.9 17	3.4% 8.5 4	5.1% 16.2 6	5.3% 118
<100000 5	21.9% 22.3 16	24.7% 17.0 18	13.7% 11.2 10	16.4% 7.4 12	12.3% 5.2 9	11.0% 10.0 8	3.3% 73
<150000 6	28.6% 21.4 20	24.3% 16.3 17	15.7% 10.7 11	7.1% 7.1 5	15.7% 5.0 11	8.6% 9.6 6	3.2% 70
>150000 7	24.8% 36.9 30	27.3% 28.1 33	14.9% 18.5 18	10.7% 12.2 13	8.3% 8.7 10	14.0% 16.6 17	5.5% 121
PERCENT TOTAL	30.5% 675	23.2% 514	15.3% 339	10.1% 223	7.2% 159	13.7% 303	100.0% 2213

CHI-SQUARE 57.60300 SIGNIFICANT AT .002 WITH 30 DEGREES OF FREEDOM

TABLE SUMMARY

TOTAL NUMBER OF UNITS IN TABLE 2213
NUMBER OF UNITS OMITTED DUE TO BLANKS 11635

Definitions of Class Variables

The variables used in generating contingency tables for this analysis are defined as follows:*

a. Population -- (CCDB) total 1970 population, Item 303; (NS) total resident population 1972-73, Question 16a(2).

b. Yearly Growth Rate -- (CCDB) computed from percent population change, 1960-1970, Item 305.

c. Percent Low Income -- (CCDB) percent of all families below the low income level, Item 368.

d. Per Capita Expenditures -- (CCDB) per capita expenditures (excluding capital outlays), Item 419.

e. Per Capita Debt -- (CCDB) debt outstanding, Item 425, divided by population, as in (a) above.

f. Median Family Income -- (CCDB) median family income for all families, Item 361.

g. Per Capita Revenue -- (CCDB) per capita total general revenue (excluding interlocal revenue), Item 411.

h. Percent of Families with Income "less than" X Dollars -- (CCDB) percent of families with family income in 1969:

    (i) less than $3,000 (Item 354)

    (ii) from $3,000 to $4,999 (Item 355)

    (iii) from $5,000 to $6,999 (Item 356)

    (iv) from $7,000 to $9,999 (Item 357)

    (v) from $10,000 to $14,999 (Item 358)

---

* Items are identified by "CCDB" for items occurring in the City and County Data Book, Table 6, and by "NS" for items occurring in the Needs Survey.

(vi) from $15,000 to $24,999 (Item 359)

(vii) greater than $25,000 (Item 360).

i. Percent Sewered -- (NS) sum of resident [Question 16c(2)R] and non-resident [Question 16c(2)N] population receiving collection from this facility 1972-73, divided by population [as in (a) above], all multiplied by 100.

j. Excess Treatment Capacity -- (NS) ratio of present design flow 1972-73 [Question 17a(3)] to total flow 1972-73 [Question 17a(1)], minus unity, all multiplied by 100.

k. Industrial Share -- (NS) ratio of total industrial flow 1972-73 [Question 17b(1)] to total flow 1972-73 [Question 17a(3)], multiplied by 100.

APPENDIX F

EXAMPLE OF SIMULATION MODEL CALCULATION

Consider the timestream shown in Figure 4-1c, for per capita municipal cost for Branch 12, biological treatment, with a 50 percent capital grant and 25 percent operation and maintenance grant. The following demonstrates how some numbers on the case 1 curve, for 25,000 initial population, zero percent industrial load, and 1 percent growth rate, are calculated. There are three sets of capital and operation and maintenance costs which must be computed: $S(P_2)$; $U(P_2)$; and $B(\Delta P_{32})$. In this example we will illustrate how the capital costs for $S(P_2)$ and $U(P_2)$ are computed as well as the first year operation and maintenance costs for $S(P_2)$, the first year per capita total cost (unsubsidized), and the first year per capita total cost with a 50 percent capital grant and 25 percent operation and maintenance grant.

BRANCH 12

$$S(P_2) \quad : \quad U(P_2) \quad : \quad B(\Delta P_{32})$$

CAPITAL COSTS

1. $S(P_2) = S(30202.7)$

$$Q = (120 \text{ gpcd})\,(30202.7\text{p}) = 3.624 \text{ mgd}$$

$$\text{P.E.} = (49)\,(3.624)\,(200) = 35518$$

$$\begin{aligned} S(30202.7) &= (.00812)\,(35518)^{.461}\,(3.624)^{.262} \\ &\quad + .0125(3.624)^{.48} \\ &\quad + 0.0575(3.624)^{.65} \\ &\quad + 0.0224(3.624)^{.59} \\ &\quad + 0.326(3.624)^{.54} \\ &\quad + 0.015(3.624)^{.56} \\ &= 1.425 + 0.023 + 0.133 + 0.048 + 0.653 + 0.031 \\ &= 2.313 \end{aligned}$$

Equal payment factor, 30 years, 6% =

$$\frac{.06}{1-\left(\frac{1}{1.06}\right)^{30}} = 0.0726$$

Equal payment amount =

$$0.0726(2.313 \text{ \$M}) = \$168,000$$

First year per capita capital =

$$\frac{\$168,000}{25,250} = \$6.65$$

Tenth year per capita (from decision 1) =

$$\frac{\$168,000}{27,615.6} = \$6.08$$

2. $U(P_2) = U(30202.7) = (0.122)\ (3.624)^{.656}$

$$= 0.2839 \text{ \$M}$$

Equal payment amount =

$$(0.0726)\ (0.2839 \text{ \$M}) = \$20,612$$

Tenth year per capita capital (from decision 2) =

$$\frac{\$20,612}{27,615.6} = \$0.75$$

Tenth year per capita capital (total) =

$$\$6.08 + 0.75 = \$6.83$$

OPERATION AND MAINTENANCE COSTS

3. First year O&M cost for $S(P_2)$ is gotten using first year population 25,250:

$$Q = 120 \text{ gpcd } (25{,}250\text{p}) = 3.03 \text{ mgd}$$

$$\begin{aligned}\text{Cost} &= (.042)\ (3.03)^{.876} \\ &\quad + (.0021)\ (3.03)^{.452} \\ &\quad + (.0095)\ (3.03)^{.712} \\ &\quad + (.0015)\ (3.03)^{.530} \\ &\quad + (.063)\ (3.03)^{.706} \\ &\quad + (.0089)\ (3.03)^{.540} \\ &= 0.1109 + 0.0035 + 0.0209 + 0.0027 \\ &\quad + 0.1378 + 0.0162 \\ &= 0.292 \text{ \$M}\end{aligned}$$

First year per capita O&M cost

$$= \frac{\$292{,}000}{25{,}250} = \$11.56$$

4. First year per capita total cost (unsubsidized)

$$= \$6.65 + 11.56 = \$18.21$$

5. First year per capita total cost (subsidized at 50% capital and 25% O&M)

$$= .50(\$6.65) + .75(\$11.56)$$

$$= \$12.00$$